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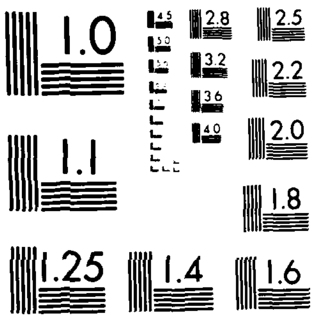
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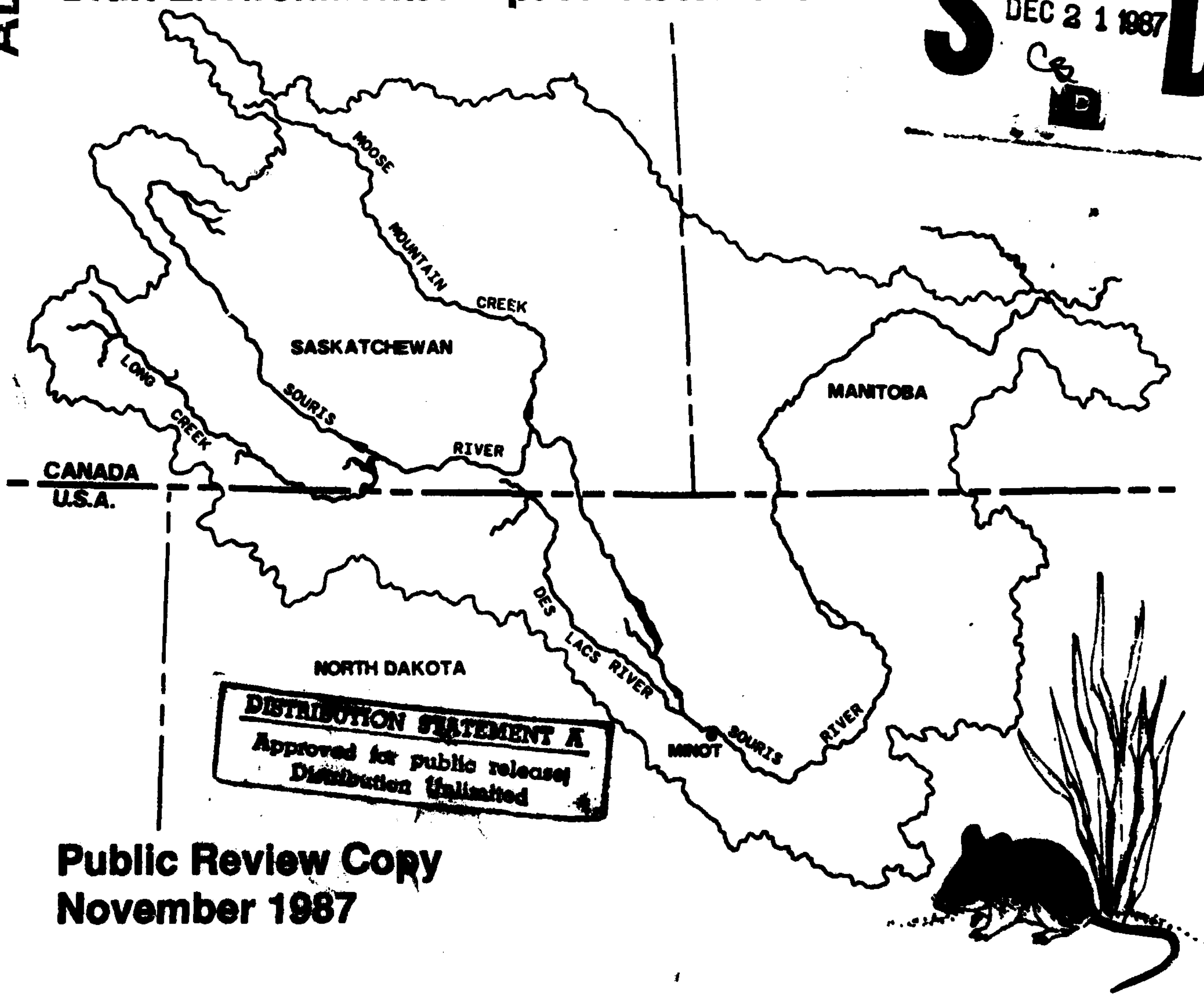
Souris River Basin Project

Saskatchewan, Canada - North Dakota, U.S.A.

General Plan Report and Draft Environmental Impact Statement



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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The authorized Souris River Basin project is a flood control project for urban and rural reaches of the Souris River in North Dakota. The flood control features in Canada include flood storage in Alameda and Rafferty reservoirs in Saskatchewan, Canada, and the operation of a proposed Boundary to Rafferty reservoir diversion and the existing Boundary Dam for flood control purposes in North Dakota. Features in the United States include modification of the gated outlet structure at the existing Lake Darling Dam for flood control; mitigation to U.S. Fish and Wildlife Service for project-related impacts; compensation to adversely impacted properties in reaches impacted by project operation in North Dakota and Manitoba; and a water control plan to release flood storage safely downstream.

The purchase and operation of flood storage in Saskatchewan is a joint effort between Canada and the United States.

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SOURIS RIVER BASIN PROJECT
SOURIS RIVER, NORTH DAKOTA

GENERAL PROJECT REPORT

PUBLIC REVIEW COPY

NOVEMBER 1987

SOURIS RIVER BASIN PROJECT
SOURIS RIVER, NORTH DAKOTA

GENERAL PROJECT REPORT

SYLLABUS

The authorized Souris River Basin project is a flood control project for urban and rural reaches of the Souris River in North Dakota. The project involves flood control features in Canada and the United States. Features in Canada include flood storage in Alameda and Rafferty reservoirs in Saskatchewan, Canada, and the operation of a proposed Boundary to Rafferty reservoir diversion and the existing Boundary Dam for flood control purposes in North Dakota. Features in the United States include modification of the gated outlet structure at the existing Lake Darling Dam for flood control; mitigation to U.S. Fish and Wildlife Service for project-related impacts; compensation to adversely impacted properties in reaches impacted by project operation in North Dakota and Manitoba; and a water control plan to release flood storage safely downstream.

The purchase and operation of flood storage in Saskatchewan is a joint effort between Canada and the United States. When construction is completed in 1991, the project will provide water supply and flood control benefits to the Province of Saskatchewan, provide 100-year flood protection for the city of Minot, North Dakota, and significantly reduce flood damages along the main stem of the Souris River in North Dakota.

SOURIS RIVER BASIN PROJECT

SOURIS RIVER, NORTH DAKOTA

GENERAL PROJECT REPORT

PERTINENT DATA

Project Authorization - 1986 Water Resources Development Act, Public Law 99-662, approved 17 November 1986.

Project Purpose - Flood control.

Project Location - Souris River, Saskatchewan, Canada, and North Dakota, USA.

Rafferty Dam and Reservoir

Drainage Area (sq. mi.)

Total	2,262 (5,861 sq km)*
Effective Catchment Area	941 (2,437 sq km)*

Controlling Elevations

Conservation pool	1806.10 ft (550.5 m)
Reservoir design pool	1817.59 ft (554.0 m)
Reservoir maximum pool	1817.59 ft (554.0 m)

Reservoir Design Pool Surface Area

Conservation pool	12,050 acres (4,800 ha)
Total flooded area	15,400 acres (6,230 ha)

* Figures have been changed. Revisions will be provided by Souris Basin Development Authority.

Storage	Volume (acre-feet)
Conservation pool (elevation 550.5 M)	356,400 (dam^3)*
Maximum drawdown (elevation 547.5 M)	247,500 (dam^3)*
Design pool (elevation 554.0 M)	513,000 (dam^3)*
Maximum flood control storage (elevation 547.5-554.0 M)	265,500 (dam^3)*

Dam Fea[illegible]es

Embankment lengtn	2,100 ft (640 m)*
Embankment crest elevation	1824.1 ft (556.0 m)*
Spillway crest elevation (service and emergency)	1804.46 ft (550.0 m)*
Spillway length (service and emergency)	49.21 ft (15 m) 722 ft (220 m)*
Outlet works	One low level modified horseshoe* 9.84 ft (3 m) high 4.92 ft * (1.5 m) radius. *

Spillway

Number of gates	Three*
Size of gates	14.76 x 13.12 ft (4.5 x 4.0 m)*
Crest elevation	1804.46 ft. (550.0 m)*
Crest length (net)	39.37 ft (12 m)*
Design discharge	7,770 cfs (220 m^3/s)*

Outlet Works

Type	Low level conduit controlled by slide gate*
Number of conduits	1*
Design discharge	2,300 cfs (65 m^3/5)*

Alameda Dam and Reservoir

Drainage Area (sq. mi.)

Total	2,008 sqm (5,203 sq km)
Effective catchment area	763 sqm (1,976 sq km)

Controlling Elevations

Conservation pool	1883.20 ft (574.0 m)
Reservoir design pool	1899.61 ft (579.0 m)
Reservoir maximum pool	1899.61 ft (579.0 m)

Reservoir Design Pool Surface Area

Conservation pool	3,300 acres ( )*
Total flooded area	5,470 acres (2,150 ha)

Storage	Volume (acre-feet)
Conservation pool (elevation 574 M)	78,300 (dam^3)*
Maximum drawdown (elevation 569 M)	37,140 (47,000 dam^3)*
Design pool (elevation 579 M)	148,660 (177,000 dam^3)*
Maximum flood control storage (Elevation 569-579 M)	111,600 (130,000 dam^3)*

Dam Features

Embankment length	3,940 ft (1200 m)
Embankment crest elevation	1902.9 ft (580 m)
Spillway crest elevation (service and emergency)	1872.70 ft (570.8 m)
Spillway length (service and emergency)	131.23 ft (40.0 m)
Outlet works	One low level circular conduit 2.3 m diameter

Spillway

Number of gates	Six
Size of gates	18.04 x 19.69 ft (5.5 x 6.0 m)
Crest elevation	1872.70 ft
Crest length (net)	108.27 ft (33.0 m)
Design discharge	2,130 cfs (650 m^3/s)

Outlet Works

Type	Low level conduit controlled by slide gates
Number of conduits	Not available
Conduit size	Not available
Design discharge	Not available

Boundary Dam and Reservoir — Data to be provided by SBDA

Boundary Diversion Channel to Rafferty Reservoir — Data to be provided by SBDA

Lake Darling Dam and Reservoir

Drainage Area (square miles)

Total	9,166
Primary contributing	3,400
Secondary contributing	4,630
Noncontributing	1,130

Controlling Elevations (feet)

Conservation pool	1597
Reservoir design pool	1601
Reservoir maximum pool	1601

Reservoir Design Pool Surface Area

Conservation pool	11,300
Total flooded area	13,000

Storage	Volume (acre-feet)
Conservation pool (elevation 1597)	110,000
Maximum drawdown (elevation 1591)	53,000
Design pool (elevation 1601)	158,600
Maximum flood control storage (elevation 1591 - 1601)	105,600
Existing controlled storage (elevation 1598)	121,600

Existing Dam

Embankment length	3,700 ft
Embankment crest elevation	1606
Spillway crest elevation (service and emergency)	1598 and 1602
Spillway length (service and emergency)	320 ft and 250 ft
Outlet works	Two slide gates 12 ft W x 10 ft H

Modified Dam Outlet Works

Type	
Number of conduits	Design data
Conduit size	not available
Design discharge (W Elevation 1591)	5,000 cfs

Levee and Channel Modification

Burlington to Minot

Design capacity	5,000 cfs
Total length of levees	5.4 miles
Channel modifications	2.0 miles

Sawyer

Design capacity	5,500 cfs
Total length of levees	0.8 mile

Velva

Design capacity	14,700 cfs
Total length of levees	1.9 miles
Channel modifications	0.9 mile
Channel cutoff	0.5 mile
Channel-barrier structures	Two
Channel-control structure	One

Interior Drainage in Local Protection Areas

Minot to Burlington

Gated gravity outlets	Seven
Pumping stations	Six
Intercepting storm sewer	1,565 feet

Sawyer

Gated gravity outlet	One

Velva

Gated gravity outlet	Seven
Pumping stations	One
Intercepting storm sewer (new)	3,870 feet

Rural Measures	106 residences downstream from dam

Project Economics

Total first costs (October 1987)	$73,736,000
Total average annual costs (5 1/8 percent)	4,111,100
Total average annual benefits (includes Velva)	7,312,800
Benefit-cost ratio	1.8

SOURIS RIVER BASIN PROJECT

SOURIS RIVER, NORTH DAKOTA

GENERAL PROJECT REPORT

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SOURIS RIVER BASIN PROJECT
SOURIS RIVER, NORTH DAKOTA

GENERAL PROJECT REPORT

THE REPORT

The purpose of this report is to document the authorized project and impacts. Several features of this project are common with the 4-foot raise of Lake Darling project and have been analyzed as part of the authorization for the Lake Darling Project. Features common to the Souris River Basin project and the Lake Darling project are shown in Table 1 and discussed in detail in Design Memorandum No. 3, General-Project Design Supplement No. 3, Lake Darling Flood Control Project, Souris River, North Dakota, December 1984, revised July 1985, and related design memorandum and reports. Features that have been modified or added as part of the Souris River Basin project will be discussed in detail in this report.

GENERAL

The Souris River Basin project is the third phase of the total flood control plan for the Souris valley in North Dakota. The channel modification in Minot, which was authorized in 1970 and completed in 1979, was the first phase of construction. The Velva levee project, which was authorized in 1982 and scheduled for completion in 1987, is the second phase of construction. In 1970, the Burlington dam project was authorized as the second phase of the flood control plan. However, because of the controversial nature of the Burlington dam portion of the project, a scaled down version was pursued by local interests. The resulting action was the authorization in the 1982 Energy and Water Development Appropriations Act of December 4, 1981 (Section 111 of Public Law 97-88), to raise Lake Darling by approximately 4 feet and to implement upstream and downstream flood control measures. In addition,

Table 1
Souris River Basin Project Which Includes Common Features of the Lake Darling 4-Foot Raise Project and Saskatchewan Works

Saskatchewan Features:

Purchase Flood Storage in Rafferty Dam
Purchase Flood Storage in Alameda Dam
Purchase Operation and Maintenance of Rafferty, Alameda, Boundary Dam, and Boundary to Rafferty Reservoir Diversion for 100-Year Flood Protection at Minot, North Dakota.

Common Features of Lake Darling 4-Foot Raise:

Lake Darling Operation Plan
Lake Darling Outlet Works (1)
Refuge Structures:

Upper Souris Refuge

Provide Heaters/Actuators on Dam 96
Upgrade Dam 96 Gated Structure
Provide Water Supply to Ponds 96 A and B
Provide Water Supply to Pool 87

J. Clark Salyer Refuge

Provide Carp Control Barrier
Provide Heaters/Actuators on all Five Dams
Upgrade and Raise Dam 326
Upgrade and Raise Dam 332
Upgrade and Raise Dam 341
Add Low Flow Structure on Dam 320

Urban Levees:

Johnson's Addition
Brooks Addition
Talbott's Nursery
Country Club Acres and Robbinwood Estates
King's Court and Rostad's Addition
Tierrecita Vallejo
Sawyer
Renville County Park
Velva (Completed)
Minot Channel (Completed)

Rural Improvements and Flowage Easements
Flood Warning System
Compensation to Manitoba

(1) The gated outlet works and appurtenant structures of the existing dam at Lake Darling will be redesigned and constructed to allow operation for flood control.

the Senate Appropriations Committee, in report 97-265, October 28, 1981, directed that the Corps of Engineers should take no further action to construct the Burlington dam until expressly directed to do so by the Committee. The raise of the dam at Lake Darling, North Dakota, by approximately 4 feet and the implementation of upstream flood control measures has been placed in a deferred status following authorization of the Souris River Basin project. On August 2, 1984, the Senate Committee on Environmental and Public Works, 98th Congress, 2nd session adopted a resolution which authorized the Corps to investigate the feasibility of a Canadian multipurpose reservoir plan in which the United States would purchase flood storage in Saskatchewan, Canada. Based on reconnaissance studies completed in September 1986, the Corps recommended the implementation of the Souris River Basin project which assumes the Minot flood channel and levees at Velva are in place and fully operational. The remaining portion of the plan includes the purchase of approximately 400,000 acre-feet of flood storage operation and maintenance in Saskatchewan, modification of the gated outlet of Lake Darling Dam and downstream flood control measures.

The 1986 Water Resources Development Act authorized the Souris River Basin project and the purchase of flood storage in Canada. If, however, it is determined by the Corps that an agreement for flood storage with Canada cannot be completed, future works will proceed according to Section 111 of the 1982 Energy and Water Development Appropriations Act.

PROJECT AUTHORIZATION

Current authorization for the expanded Souris River Basin project is included in Section 1124 of the 1986 Water Resources Development Act, Public Law 99-662, which was signed on 17 November 1986. The authorizing language for the Souris River Basin project states:

> Sec. 1124. (a)(1) On behalf of the United States, the Secretary, in consultation with the Secretary of State, is authorized to cooperate with governments in Canada to study

and to construct reservoir projects for storage in the Souris River Basin in Canada to provide flood control benefits in the United States.

(2) The Secretary is authorized further to participate in financing the storage referred to in paragraph (1) of this subsection to a maximum contribution of $26,700,000 in the event that only one reservoir, known as the Rafferty project, is constructed in Canada, or to a maximum of $41,100,000, in the event two reservoirs, known as the Rafferty and Alameda projects, are constructed in Canada. The amount of any such contribution shall be determined by an allocation of costs, based on the proportionate use of these projects for flood control in the United States and water supply in Canada.

(b) Upon completion of the structure or structures in Canada, as agreed upon between the United States and governments in Canada, the construction of Burlington dam, North Dakota, as authorized by Section 111 of the Energy and Water Development Appropriations Act, 1982 Public Law 97-88; 95 Stat. 1138, shall no longer be authorized. Should the Secretary determine that an agreement between the United States and governments in Canada cannot be consummated, he shall proceed with the work authorized by Section 111 of such Act, including raising the dam structure and including storage capacity for flood control purposes, with such work to be considered a non-separable element of the flood control project for Minot, North Dakota, authorized under Section 201 of the Flood Control Act of 1965.

(c) The Secretary is authorized further to make such modifications as necessary to the existing Lake Darling, exclusive of the modifications authorized by Section 111 of The Energy and Water Development Appropriation Act, 1982,

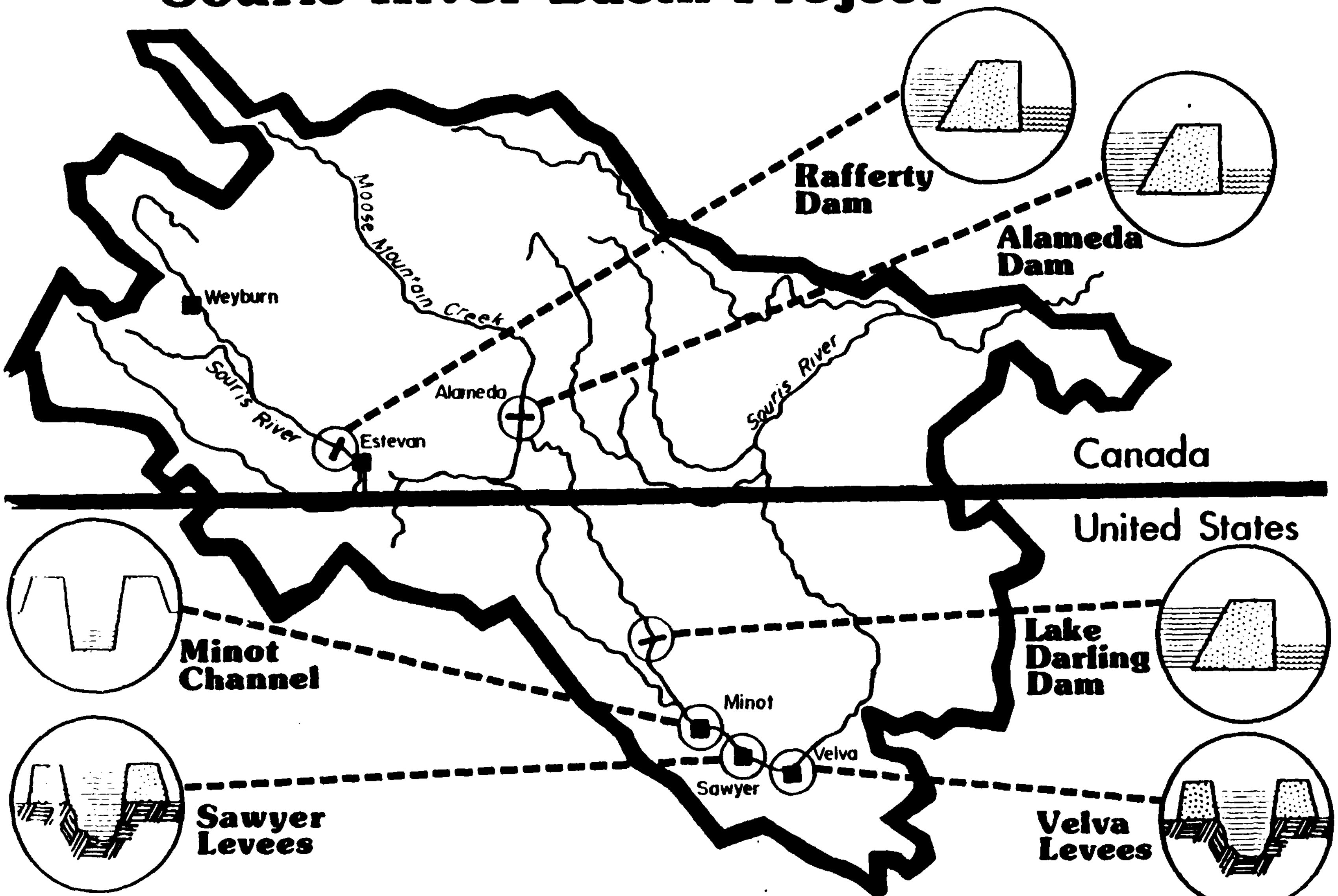
for the purpose of effective operation of the project for flood control, with such work considered to be a nonseparable element of the flood control project for Minot, North Dakota, authorized under section 201 of the Flood Control Act of 1965, and to operate and maintain the project with such modifications in a manner compatible with the migratory waterfowl-refuge purpose of the project.

(d) The non-Federal share of the cost of contributions to governments in Canada, as authorized by this section, shall be in accordance with title I of this Act for the amount over $23,600,000. The total Federal cost of work authorized by this section and by Section 111 of the Energy and Water Development Appropriation Act, 1982, as modified herein, and including related dam safety measures, is $69,100,000.

If agreement between the United States and governments in Canada cannot be consummated, the authorizing language for the scaled-down reservoir project in the Energy and Water Development Appropriations Act 1982, Section 111 of Public Law 97-88 (95 Stat. 1138) states:

The Chief of Engineers is, hereby, directed to raise the dam at Lake Darling, North Dakota, by approximately four feet and to implement upstream and downstream flood control measures.

Souris River Basin Project



LOCAL COOPERATION

By resolution dated July 19, 1969, the Ward County Water Management Board agreed to sponsor a channel improvement project at Minc· and to meet the local cooperation requirements for an overall flood protection plan. When the Lake Darling project was authorized, it was recognized that there was a need for a joint board representing the counties affected by the project to serve as local sponsor. On August 18, 1982, the Ward County Water Resources District provided a letter of intent to accept the responsibilities as the lead agency of a joint organization. The letter indicated a willingness to work in good faith with the Administration of the United States in the planning and funding process for the project.

On June 6, 1983, the representatives of the Water Resource Districts for Ward, Renville, McHenry, and Bottineau Counties and the Oak Creek drainage area agreed to become members of a Souris River Joint Board for flood control, which would serve as a local sponsor for the project. The general letter of intent to serve as a local sponsor was signed by their president on June 14, 1983, and a letter verifying legal and financial capability of the board to serve as local sponsor was provided on February 3, 1984. In September 1984, the four counties signed the Joint Exercise of Powers Agreement which formally established the Souris River Joint Board.

Since the Secretary of the Army recommended separating the Velva feature from the rest of the Lake Darling project, a separate local cooperation agreement was drawn up for that feature. This local cooperation agreement was signed by the local sponsor on 19 November 1984 and by the District Engineer on 20 November 1984.

In August 1985, the Souris River Joint Board provided a letter of intent to serve as the local sponsor for participation in the Souris River Basin project. In September 1985, the Joint Exercise of Power Agreement was amended to give the Board the authority to provide local sponsorship

and was amended in February 1987 to allow the Board to incur financial obligation and make payment of the local sponsor's share of the project costs. Items of the local cooperation agreement for the project include:

1. Provide without cost of the United States all lands, easements and rights-of way, including suitable areas for borrow and disposal determined by the Chief of Engineers necessary for construction. Before the award of any construction contract, furnish to the Government rights-of-entry to all lands required for the construction contract.

2. Provide twenty-five (25) percent of the cost of contributions to governments in Canada over the term of construction for the amount in excess of $23,600,000.

3. Provide twenty (20) percent of total nonstructural flood proofing project costs for downstream rural improvements.

4. Hold and save the Government free from damages arising from the construction, operation, and maintenance of all project features, except for damages that are the fault of or are caused by the negligence of the Government or its contractors.

5. Operate, maintain, replace, and rehabilitate those portions of the project transferred to the Board upon completion, in accordance with regulations or directions prescribed by the Government.

6. Accomplish or arrange for accomplishment at no cost to the Government of all alterations and relocations of buildings; highways; railroads; bridges (other than railroad bridges); storm drains; utilities; cemeteries; and other facilities, structures, and improvements determined by the Government, to be necessary for construction of the project (except for public utilities that pass beneath, through, or over project structures and could damage the

project if they failed and those associated with flood proofing measures for rural improvements).

7. Prescribe and enforce regulations to prevent physical encroachment on downstream constructed drainage channel capacities for regulation of the reservoirs, and, if drainage channel capacities or ponding areas for interior drainage are impaired, provide substitute storage capacity or equivalent pumping capacity promptly without cost to the Government.

8. Inform affected interests at least annually that the project will not provide complete flood protection.

9. Provide guidance and leadership in preventing unwise future development of the floodplain by use of appropriate floodplain management techniques to reduce flood protection.

10. Hold and save the United States free from damages from water rights claims resulting from construction and operation of the project.

11. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved January 2, 1971, in acquiring lands, easements, and rights-of-way for construction and subsequent maintenance of the project and inform affected persons of pertinent benefits, policies, and procedures in connection with said act.

12. Comply with all applicable Federal and State laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and Department of Defense Directive 5500.11 issued pursuant to it and published in Part 300 of Title 32, Code of Federal Regulations, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

13. Require that the political subdivisions benefited by the project participate in the National Flood Insurance Program to maintain the existing flood warning system in cooperation with the National Weather Service and administer and enforce floodplain regulations in accordance with State law.

14. Obtain all necessary State and local permits for the construction and operation of the project.

INVESTIGATIONS

Reconnaissance investigations were conducted during the period October 1984 to August 1985 to determine the feasibility of a United States purchase of flood storage in Saskatchewan, Canada, and the operation of these flood storages for flood damage reduction in the United States. Investigations prior to this study are discussed in Design Memorandum No. 3, General, Project Design Supplement No. 3, Lake Darling Flood Control Project, Souris River, North Dakota, Revised July 1985. The reconnaissance investigation included a detailed hydrologic and economic evaluation of several measures and plans and a preliminary evaluation of their environmental and social impacts. Based on these evaluations, a plan involving the purchase of flood storage in Saskatchewan, Canada, and compatible modification to the Lake Darling Project was recommended for further study; a basis for purchase of flood storage in Saskatchewan was established; and legislation authorizing the project was passed. Funding of Saskatchewan features is pending in Congress, and common features of the authorized Lake Darling project which are compatible with the Souris River Basin project are being implemented.

Further investigations are needed to finalize agreements with locals and Canada and to design and construct common features from the Lake Darling project and downstream works. Items to be considered are:

- Compensation to properties adversely affected by project operation.
- Design and construction of gated outlet at Lake Darling.
- Modification of refuge structures in accordance with mitigation requirements.
- Compensation of project impacts in Manitoba.

HYDROLOGY AND HYDRAULICS

GENERAL BASIN CHARACTERISTICS

The Souris River Basin encompasses 24,000 square miles in southeastern Saskatchewan, southwestern Manitoba, and northwestern North Dakota. Of the total area, 15,000 square miles (62 percent) are in Canada, and 9,000 square miles (38 percent) are in the United States.

The Souris River originates in Saskatchewan and flows southeast for 217 miles before entering the United States near Sherwood, North Dakota. It continues southeast, passing through Minot, Sawyer, and Velva, then flows northeast to Towner, North Dakota, where it gradually assumes a northwest heading and reenters Canada near Westhope, North Dakota. The river travels 358 miles from near Sherwood to Westhope and another 154 miles in Manitoba before emptying into the Assiniboine River, which flows into the Red River of the North at Winnipeg, Manitoba. Important tributaries of the Souris River are the Des Lacs, Wintering, and Deep Rivers, Willow Creek, and Gassman Coulee in North Dakota and Moose Mountain Creek and Long Creek in Saskatchewan. The Des Lacs River, with a drainage area of 1,050 square miles, enters the Souris River 7 miles upstream of Minot.

HYDROLOGIC DATA

Appendix A contains the operating plan and area capacity curves for the project. Hydrologic data and analysis of compatible Lake Darling features are contained in prior reports.

GEOLOGY AND SOILS

The Souris River Basin lies in the Drift Prairie section of the Central Lowland physiographic province and in the Coteau Du Missouri, which forms the eastern border of the Great Plains physiographic province. Four major geologic and topographic features further subdivide these major sections. These are the Missouri Escarpment, ground-moraine plain, the lake bed of glacial Lake Souris, and the southwestern portion of the Turtle Mountain. The Souris River valley upstream from Verendrye is in the ground-moraine plain and was carved when the river was swollen with glacial meltwater. The existing condition in the valley is one of a small stream in a prominent, oversized valley. Downstream from Verendrye, the river valley is formed in the glacial Lake Souris area and is a subtle feature that in places is barely perceptible.

Unconsolidated surface deposits in the basin are of two types: recent alluvium and Pleistocene glacial deposits. Recent alluvium comprises only a small portion of the surface materials and consists of clay, silt, fine-to-medium sand with minor amounts of coarse sand, and gravel. Significant alluvial deposits are restricted to the valleys of the Souris and Des Lacs Rivers where they generally exceed 50 feet in thickness. The glacial material consists primarily of morainal deposits and sediments of glacial Lake Souris. Morainal deposits are composed of an impervious, stony clay till with thin seams, lenses, and channels of sand and gravel. The deposits of glacial Lake Souris range in thickness from a feather-edge to more than 70 feet. Material in the Lake Souris area is predominantly silt and moderately-to-poorly graded sand with sand and gravel beach and other near-shore deposits.

PLANS INVESTIGATED

Several flood damage reduction plans have been studied for the Souris River Basin. They are discussed in Design Memorandum No. 3, General Project Design Supplement No. 3, Lake Darling Flood Control Project, Souris River, North Dakota, revised July 1985. Recent studies have

included consideration of past plans as well as plans which include flood control works constructed in the Souris River Basin in the United States and Canada. Results of the investigation are presented in the August 1986 Reconnaissance Report, Souris River Basin Study. As part of the reconnaissance investigation, the following measures were considered separately and in combination as plans for reducing flood damages in the United States.

MEASURES EVALUATED

- 4-foot raise of Lake Darling and operation for flood control.
- Modification of the existing Lake Darling Dam gates and operation for flood control.
- Purchase of flood storage in the proposed Rafferty reservoir on the Souris River near Estevan, Saskatchewan, and operation for flood control in the United States.
- Purchase of flood storage in the proposed Alameda reservoir on Moose Mountain Creek near Oxbow, Saskatchewan, and operation for flood control in the United States.
- Purchase of the flood operation of the proposed Boundary diversion channel near Estevan, Saskatchewan, between existing Boundary Reservoir and the proposed Rafferty reservoir for flood control in the United States.
- Purchase of the operation of existing Boundary Dam on Long Creek near Estevan, Saskatchewan, for flood control in the United States.
- The construction of the levees in Minot, North Dakota, to provide up to 100-year flood protection to the city of Minot, North Dakota.

The study concluded that the combination of the following measures offered the best flood damage reduction plan to the United States:

> Modification of the existing Lake Darling gates and operation for flood control; purchase of flood storage in the proposed Rafferty reservoir on the Souris River near Estevan, Saskatchewan, and operation for flood control in the United States; purchase of flood storage in the proposed Alameda reservoir on Moose Mountain Creek near Oxbow, Saskatchewan, and operation for flood control in the United States; and purchase of the operation of the existing Boundary Dam on Long Creek near Estevan, Saskatchewan, for flood control in the United States.

PLANS SCREENED FOR FINAL CONSIDERATION

PLAN 1 - NO ACTION

The no action alternative was the base condition upon which the effectiveness of all other alternatives was evaluated. It involved reliance on existing floodplain management programs and no further action other than possible expansion of existing programs. These programs included flood storage provided behind Lake Darling Dam, the Minot channel project, and by the Velva project, flood warning systems and emergency protection measures, flood insurance, and floodplain regulations. The base condition assumed that the U.S. Fish and Wildlife Service would upgrade Lake Darling Dam to meet current engineering standards so that it can be reliably operated for flood control. Operation of the dam was assumed to be similar to past operation. The base condition also assumed that Saskatchewan would construct Rafferty and Alameda dams to capture their rightful share of the basin's water supply. With the authorization of the 4-foot raise of Lake Darling, this plan is the least viable of the three plans.

PLAN 2 - LAKE DARLING FLOOD CONTROL PROJECT

The project involved a 4-foot raise of the existing Lake Darling Dam, fish and wildlife mitigation measures, upgrading Sawyer and Velva and six subdivisions between Burlington and Minot, and a combination of structural and nonstructural measures for approximately 106 rural dwellings between Burlington and the J. Clark Salyer Refuge. All of the features below the dam would be designed to safely pass the 5,000-cfs design flow from the dam plus local inflow below the dam. Lake Darling Dam would control all floods up to the estimated 25-year flood level. No further control would be provided over floods from the Des Lacs River or from the drainage area around Minot. Thus, recognizing the probability of flows from all three sources exceeding 5,000 cfs at Minot as an independent event, this plan would provide the city of Minot with about 25-year flood protection. The details of the project are contained in Design Memorandum No. 3, Lake Darling Flood Control Project, Souris River, North Dakota, revised July 1985.

PLAN 3 - SOURIS RIVER BASIN PROJECT

The project contains many of the features of the Lake Darling flood control project. Under this plan, flood control is provided by the one-time purchase of flood storage in Saskatchewan and eliminating the need for the raise of the Lake Darling structure. Additional features include modification of existing Lake Darling gate outlet and operation for flood control, upgrading levees at Sawyer and six subdivisions between Burlington and Minot, a combination of structural and nonstructural measures for rural dwellings between Sherwood and Westhope, North Dakota, modification of U.S. Fish and Wildlife structures in the Upper Souris and J. Clark National Wildlife Refuges, and modification of a return flow agreement with Manitoba. These improvements would compliment the completed levee at Velva and channel at Minot, North Dakota. Flood storages would be operated for flood control in the United States and would control all floods up to the estimated 100-year flood at Minot, North Dakota. All of the features

between Sherwood and Lake Darling would be designed to safely pass the 4,000 cfs design flow. As with the Lake Darling plan, all of the features below Lake Darling Dam would be designed to safely pass the 5,000 cfs design flow plus local inflow below the dam.

DESCRIPTION OF AUTHORIZED PROJECT

GENERAL

The Souris River Basin project is composed of the following general features:

- Purchase of flood storage, flood operation, and maintenance in Saskatchewan.
- Modification of the existing Lake Darling Dam gated outlets.
- Flood protection and compensation for adversely impacted properties.
- Mitigation of impacts to fish and wildlife resources with construction of mitigation features in the Upper Souris and J. Clark Salyer National Wildlife Refuges.
- A water control plan (operating plan) to safely release flood storages which includes flood forecasting, operation instruction, and planned maintenance of system works.
- Compensation to Manitoba.

PURCHASE OF FLOOD STORAGE, OPERATION, AND MAINTENANCE IN SASKATCHEWAN

The United States will purchase flood storage in Rafferty dam and Alameda dam in Saskatchewan, Canada, for a maximum amount of $41.1 million (U.S. - October 1985). The purchase includes the operation and maintenance of these storages by the Saskatchewan government for flood

control in the United States in conjunction with existing Boundary Dam in Saskatchewan and existing Lake Darling Dam in North Dakota. The objective of the flood control operation is to achieve up to 1-percent chance flood protection at Minot, North Dakota. The purchased storages and their respective elevation in each reservoir are shown in the following table:

Table 2 - Storage Requirements

	Rafferty	Alameda	Lake Darling	Boundary Dam (1)	Boundary to Rafferty Diversion (2)
Total storage in acre-feet	265,500	111,600	105,600	13,600	20,000
Starting pool	547.5 m	569.0 m	1,591 ft	1830.0 ft	
Full supply level (FSL)	550.5 m	574.0 m	1,597 ft	1840.0 ft	
Top of flood pool (TFP)	554.0 m	579.0 m	1,601 ft	1840.0 ft	

*Data changes will be provided by SBDA.

(1) No storage has been purchased for flood control purposes in Boundary Dam. Saskatchewan has agreed to operate Boundary Dam for flood control purposes when their water supply would not be compromised: that is typically large volume runoff events.

(2) The operating plan for these storages is discussed in Appendix A.

Rafferty Dam

The Souris Basin Development Authority would plan, design, and construct Rafferty dam and reservoir. The dam would be constructed approximately 6 kilometers northwest of Estevan on the Souris River. The dam would be of homogeneous earth fill construction with embankments having a side slope of 5:1. The reservoir full supply level (FSL) has been established at an elevation of 550.5 metres and would inundate 12,050 acres. The maximum flood pool elevation of 554.0 metres has a volume of 513,000 acre-feet and a surface area of , acres. Other general data include:

Dimensions:	62 feet high, 790 yards between riverbanks.
Construction:	Earth filled, rock faced.
Reservoir:	41 miles long at full storage level.
Purpose:	* Reservoir water to be used as cooling water for Shand Thermal Station. * Downstream flood control. * Water supplies for Weyburn and Estevan. * Irrigation for agricultural interests.
Construction Time:	Two years: Spring of 1988 to fall of 1989.

Alameda Dam

The Souris Basin Development Authority would plan, design, and construct Alameda dam and reservoir. The dam would be constructed approximately 15 kilometres upstream of the confluence of Moose Mountain Creek with the Souris River. At maximum flood level (579.0 metres), the reservoir has a volume of 111,600 acre-feet and surface area of 5,470 acres. Other general data include:

Dimensions:	82 feet high, 1,500 yards between riverbanks.
Construction:	Earthfilled, rock faced.
Reservoir:	15 miles long at full storage level.
Purpose:	* Downstream flood control * Recreation * Agricultural irrigation * Municipal water supply
Construction Time:	Two construction seasons starting in 1989.

Other important data on Rafferty and Alameda is shown in the pertinent data summary in the front of this report.

Boundary Dam

Boundary Dam is an existing water supply dam (49,100 acre-feet) on Long Creek tributary to the Souris River approximately 1 mile south of Estevan, Saskatchewan. The reservoir is used for cooling water for a thermal electric generating plant and for municipal water supply at Estevan. As part of the overall operating plan for Rafferty, Alameda, and Lake Darling reservoirs, Boundary Dam may need to be operated during extreme runoff events to assure 100-year flood protection at Minot, North Dakota. During certain events, Boundary Reservoir will be drawn down prior to spring runoff to control flows on Long Creek, provided that there is "high probability" that the March to May runoff volume will be sufficient to restore Boundary to its operating full supply level.

Boundary Reservoir and Diversion Channel to Rafferty Reservoir

The operation of the channel from Boundary to Rafferty reservoir and the operation of Boundary reservoir will be directed at minimizing the flood peak on the Souris River below Long Creek in harmony with the provisions of the Rafferty, Alameda, and Lake Darling operating plan. As runoff is stored in Boundary Reservoir, water may also be diverted to Rafferty reservoir. When runoff commences, forecasts of the expected inflow will be determined to attempt to minimize the peak flow on the Souris River below Long Creek. The rate of diversion and the rate of outflow from boundary will at all times depend on the elevation of Boundary Reservoir.

MODIFICATIONS OF THE LAKE DARLING GATED OUTLET

Lake Darling Dam is an earth-filled structure about 37 feet high (crest elevation 1606 feet). The dam includes a 320-foot-long service spillway (elevation 1598) on the left abutment, a 250-foot-long emergency spillway on the right abutment (crest elevation 1602) and a two-barrel gated low-level outlet works (elevation 1577). Modification at Lake

Darling Dam would include: replacement of the existing low-flow outlet works with a new conduit to allow operation of the dam for flood control purposes; and operation of Lake Darling dam in conjunction with Canadian storages during floods in accordance with the operation plan in Appendix A. Gate operation during spring ice periods is a project requirement. In addition, the existing spillway is not adequate to pass extreme flood events. A dam safety analysis will be done in the near future.

FEATURES FOR PROJECT OPERATION

During flood events, the project operation requires the controlled release of flood storages into the Souris River according to the operating plan in Appendix A. The release from flood storage is required to draw reservoir water levels down in a given year in order to provide the same storage and protection for next year's flood event. In the reach between Sherwood and Lake Darling, controlled releases will be operated for a maximum discharge of 3,200 cfs for floods up to the 50-year flood event and 4,000 cfs for floods greater than the 50-year flood event. In the reach downstream from Lake Darling, controlled releases will be operated for a maximum discharge of 5,000 cfs until June 1 and 500 cfs thereafter at Minot.

In general, all ownerships adjacent to the Souris River in North Dakota are benefitted by the project. However, portions of some ownerships are in the floodplain of the controlled releases specified by the operating plan. Urban and rural homes in some of these ownerships would be flooded by the controlled reservoir releases. Features to protect or compensate these ownerships for project operation include urban levees to protect urban areas from the maximum controlled releases, a voluntary program for providing flood protection for rural homes in the floodplain of the maximum control releases, and purchase of flowage easements on lands that would be flooded for significantly longer durations than would occur without the project. The following features have been identified:

- o Urban levee improvements at:
  - Sawyer, North Dakota.
  - Six subdivisions between Burlington and Minot, North Dakota: Johnson's Addition; Brooks Addition; Talbott's Nursery; Country Club Acres and Robbinwood Estates; King's Court and Rostad's Addition; and Tierrecita Vallejo.
  - Renville County Park.

- o Flood proofing or acquisition of rural North Dakota residences in the floodplain of the maximum controlled releases.

- o Purchase of flowage easements.

- o Modification of U.S. Fish and Wildlife Service structures in the Upper Souris and J. Clark Salyer National Wildlife Refuges.

- o Modification of the return flow agreement with Manitoba

Urban Levee Improvements

Permanent flood protection would be provided at Sawyer, the six subdivisions between Burlington and Minot, North Dakota, and Renville County Park. The level of permanent flood protection would be based on the peak 4,000 cfs release plan between Sherwood and Lake Darling and the peak 5,000 cfs release plan downstream from Lake Darling. The alignment of existing emergency levees would be followed when possible and the levees brought up to Corps standards for permanent protection. The cost for the levee construction and materials would be borne by the Federal Government, and local interests would be responsible for lands, rights-of-way, relocations, and operation and maintenance.

The emergency levee systems would be upgraded to meet current engineering standards for foundation stability and interior flood control. They would be realigned and regraded to pass the release plan peak flows. In places where levees are constructed between the channel

and adjacent development, the channel would be realigned and/or structures relocated to permit proper design of levee slopes. Riprap would be included where necessary to prevent erosion of the channel and the riverward slope of the levee.

Major interior flood control facilities include gated gravity outlets, permanent pumping facilities, temporary ponding areas, and intercepting storm sewers. The gravity outlets and storm sewers would be reinforced concrete pipe, and the gate structures would consist of a gatewell with a sluice gate.

Rural Improvements

The proposed rural improvement feature involves several alternative means of protecting rural homes that would be affected by the controlled reservoir releases. These alternatives include the following: acquisition of the home and relocation of the homeowner, construction of ring levees, or elevating the home. Access roads would also be raised, if necessary. Participation in this program would be voluntary. Flood protection would be offered to homeowners if the lowest ground elevation adjacent to their home is less than 1 foot above the computed water surface profile corresponding to the maximum controlled reservoir release rate, plus local inflow where appropriate. The design discharge for this project feature is 4,000 cfs between Sherwood and Lake Darling and 5,000 cfs downstream of Lake Darling.

The Federal Government and local sponsor for the flood control project would share the costs (80/20, respectively) of the least expensive alternative for flood protection of affected rural homes. This cost sharing arrangement is in accordance with Public Law 93-251 for nonstructural flood control measures. Homeowners could choose a more costly alternative if they are willing to pay the difference in cost. If acquisition and relocation is the least costly alternative, the homeowner would be eligible for relocation benefits in accordance with Public Law 91-646. The homeowner may also choose to buy back the house

at salvage value and move it to higher ground at his own expense. If a ring levee or elevating the home is the least costly alternative, the homeowner could choose to relocate and receive monetary assistance equal to the estimated cost of the least expensive alternative. However, under these circumstances, the homeowner would not be eligible for relocation benefits under Public Law 91-646.

Flowage Easements

Flowage easements would be purchased on lands that could be flooded for significantly longer durations during the growing season with the proposed flood control project than without it. It is currently anticipated that flowage easements would be purchased on lands inundated at flow rates of 3,200 cfs upstream of Lake Darling and 500 cfs plus appropriate local inflows downstream of Lake Darling. Rural homes within a flowage easement area would be acquired unless it is less expensive to provide flood protection through the rural improvements program.

Mitigation of Project Impacts in the USFWS Upper Souris and J. Clark Salyer National Wildlife Refuges

Project impacts would be offset by structural improvements to refuge water control structures, spillways, and dams. The recently completed evaluation of project impacts indicates the flood operation plan would adversely affect wildlife habitat throughout the North Dakota reach of the Souris River. Flood storage in Canadian reservoirs and the prolonged discharges in excess of existing conditions would damage insitu habitat and adversely impact fish and wildlife refuge operation. The following proposed measures in the Upper Souris and J. Clark Salyer Refuges have been generally agreed to by the U.S. Fish and Wildlife Service (USFWS) to offset the adverse impacts of the project operation plan and maintain continued refuge operation at a similar level of productivity. Several improvements will be completed concurrently as part of the USFWS's scheduled program to upgrade refuge structures.

Mitigation features in the Upper Souris Refuge:

- Provide heaters/actuators on Dam 96.
- Upgrade Dam 96 gated structure.
- Provide water supply to pools A, B, C, pond 96 A and B and pool 87.
- Construct a levee around a portion of pool 87 and partial removal of Dam 87 embankment.

Mitigation features in J. Clark Salyer Refuge:

- Provide carp control velocity barrier for large flows and electric weir for low flows.
- Provide heaters and actuators on one gate at each of the five structures.
- Upgrade and raise Dam 326.
- Upgrade and raise Dam 332.
- Upgrade and raise Dam 341.
- Add low-flow structures on Dam 320 for improved circulation.

Heaters and Actuators: The operating plan will require the capability to pass larger regulated flows through the refuge in early spring and late fall. Current procedures for operating the gates in the spring and fall involve time consuming manual labor for removal of ice, repair of damage, and operation of screw-type hoists.

To insure the capability to regulate storage releases, heaters and actuators (or motorized hoists) on one of the three radial gates at each refuge dam (Dams 96, 320, 326, 332, 341, 357) will be required.

Provide Water Supply to Ponds A, B, C and pools 87 and 96A: To improve the ability to provide water to these areas, a continuous piping system from Lake Darling along the west bank of the Souris River would be constructed to provide water to ponds A, B, and C and pools 87 and 96A. The existing wildlife ponds could be more intensively managed with the

additional water supply to offset adverse impacts of the project operating plan.

Partial Removal of Dam 87 Embankment and Construction of Levee: Portions of Dam 87 embankment would be removed and replaced with a raised embankment along the east bank of the Souris River. A 140-acre marsh upstream of Dam 87 would be more intensively managed at a desired rate level of 1581.0 feet and inflow rate of 25 cfs to offset project flood operation impacts.

Carp Control Structure: An electrical carp control barrier would be installed at Dam 357. The barrier would prevent carp access to upper reaches of the Souris River and thereby prevent their destruction of aquatic habitat and food for fish and waterfowl.

Upgrade Gated Structure on Dams 96, 326, 332, 341: The outlet structures for dams 96, 326, 332, and 341 are in need of major repair and need to be modified with heaters and actuators. Structures need to be upgraded as a result of problems with uneven settlement, deterioration of concrete, excessive vegetation growth, and embankment stabilization. The project operation plan would impact these structures by providing higher flows of longer duration during flood operation. The work at each site would include replacing the existing gated structures, raising the crest elevation 2 feet, and stabilizing embankments and spillways to withstand flood flows.

Add Low-Flow Structure on Dam 320 for Improved Circulation: A low-flow outlet would be provided at Dam 320 to improve water circulation and refuge management.

Compensation to Manitoba

The impacts of altered return flows in Manitoba are considered to be similar to or less than those evaluated for the Lake Darling 4-foot raise project. A special task force representing both countries was

established by the International Joint Commission to examine the Lake Darling project impacts. The preliminary task force report indicates that compensation of approximately $200,000 in a lump sum payment to the Canadian government would be adequate. A special task force is being established to do additional studies to determine acceptable compensation.

EVAPORATION SHARING

The apportionment of water between Saskatchewan and North Dakota is determined in accordance with the provisions of Article IX of the Boundary Waters Treaty, 1909, in accordance with the 1959 Interior measure for the Souris River Basin. In general, the existing orders state that, by the direction of the International Joint Commission, the International Souris Board of Control will determine the volume of natural runoff and the apportionment of the natural runoff that must be passed from Saskatchewan to North Dakota. In accordance with the existing treaty obligations and orders of the International Joint Commission, Saskatchewan must pass 50 percent of the natural flow at Sherwood to North Dakota.

In recognition of Saskatchewan's agreement to operate Rafferty dam, Alameda dam, Boundary to Rafferty diversion, and Boundary Dam for flood control in the United States, and to account for a sharing for increased evaporation from Rafferty dam and Alameda dam under certain conditions (reference Appendix A), North Dakota will provide Saskatchewan 10 percent of the natural flow as their share of the evaporation loss at Rafferty reservoir and Alameda reservoir. Under these conditions 40 percent of the natural flow will be passed to North Dakota.

OPERATION AND MAINTENANCE RESPONSIBILITIES

SASKATCHEWAN PROJECT FEATURES (RAFFERTY, ALAMEDA, AND BOUNDARY DAMS)

The operation and maintenance of Rafferty, Alameda, and Boundary Dams would be a Canadian (Saskatchewan) responsibility. The structures are owned, operated, and maintained by the Saskatchewan Water Corporation. The annual operation and maintenance costs of the dams and reservoirs and assurance that the structures were maintained to its standards would be the responsibility of the Saskatchewan Water Corporation. Any costs for inspections or maintenance required for Corps standards or more sophisticated flood forecasting methods would be a Corps cost. No additional costs have been identified at this time. Funding for additional annual costs should be the responsibility of the Corps of Engineers. U.S. costs for operation and maintenance of the structure are included in the lump sum purchase agreement for flood storage.

Table 3
Summary of U.S. Flood Operation and Maintenance Responsibilities
By Project Feature

Feature	Responsibility
Lake Darling Dam	Federal - COE
Other refuge structures (Upper Souris and J. Clark Salyer)	Federal - FWS
Other features (including urban and rural levees, access roads, and protection)	Local sponsor

LAKE DARLING DAM

The operation and maintenance of the Lake Darling Dam is a Federal responsibility. The structure is owned, operated, and maintained by the U.S. Fish and Wildlife Service. The structure is being upgraded for dam safety purposes by the USFWS using USFWS funds and for flood control purposes using Corps of Engineers funding and design criteria.

Therefore, in addition to FWS standards for operation and maintenance of the dam and Federal standards for dam safety, the Corps must be assured that the structure is maintained to Federal standards. The annual operation and maintenance costs will be higher for post-project conditions. Besides any additional inspections or maintenance required for Corps standards, the gated spillway and more sophisticated flood forecasting methods will result in higher annual costs. Funding for these additional annual costs will be the responsibility of the Corps of Engineers.

UPPER SOURIS AND J. CLARK SALYER REFUGE STRUCTURES

There will be additional costs associated with utilities needed for operation of the gate actuators and heaters in each refuge. These costs will be USFWS costs and are assumed to be offset by the savings in reduced manual labor. Current conditions require the placement of baled straw adjacent to the gates to prevent ice damage and to make it easier to remove the ice in the spring. Also, many hours are required to manually chip the ice away from the gates in the spring. With heaters, the effort required to begin gate operation each spring would be significantly reduced. The heaters would not operate throughout the winter, but rather for a period of several weeks in late winter or spring when the gates are to be adjusted. The carp control structure would require electrical service. This cost would be borne by the U.S. Fish and Wildlife Service.

DOWNSTREAM URBAN LEVEES AND RURAL FLOOD PROOFING

Local interests will be responsible for the operation of the pumping station and all related gate closures on sewers, the installation and removal of sandbags for closure structures, and the servicing and maintenance of equipment, structures, and related landscaping as necessary. Operating instructions will be provided to the appropriate local officials for completed portions of the project as these become operable. This will ensure proper operation of the partially completed

project during the extended period required for construction of the total project.

HYDROMETEOROLOGICAL NETWORK

Operation and maintenance costs for a modified hydrometeorological network have not been established at this time. Any increased U.S. cost for this system will be estimated when Saskatchewan describes the addition to the system in Canada as part of the Rafferty, Alameda future. The operation of the Gassman Coulee system includes seasonal preparation of precipitation gages; lubrication, cleaning, and adjustment of instruments; cleaning and periodic replacement of batteries; charging of propane storage tanks for thermal generators; changing of paper punch tape at the streamflow recorder; and record maintenance. The staff required to operate the floodwarning system is based upon part-time participation of full-time employees. Field maintenance of remote stations may be performed incidental to other tasks.

RESERVOIR REGULATION

FLOOD FORECASTING

The project includes the use of the existing basin-wide hydrometeorological collection and distribution network, with modification, to provide information to reservoir operating agencies for flood operation. Agencies currently involved in the network include the Water Survey of Canada, the National Weather Service, the U.S. Geological Survey, and U.S. Fish and Wildlife Service. In order for U.S. agencies to operate in time for forecasting for flood control, the following Saskatchewan gages need to be converted to real-time reporting: Moose Mountain Creek at Oxbow, Souris River at Glen Ewen, and Souris River at Roche Percee. In addition, local gage readers would be hired to obtain weekly checks at Moose Mountain Creek at Highway 9 south of Carlyle, Saskatchewan, and the Souris River downstream of Dead Lake,

Saskatchewan. An agreement between Saskatchewan, USFWS, and Corps will address the responsibility of the forecasting network for Saskatchewan and the United States. This information will be included as part of the Water Control Manual for the project. Because of the flood threats of the Des Lacs River at Gassman Coulee, two remote data stations which include a precipitation gage and stream gage will be installed on Gassman Coulee and two similar remote data stations will be installed on the Des Lacs River to serve as a flood warning system for Gassman Coulee and the city of Minot.

OPERATING PLAN

The operating plan (Appendix A) involves the coordination of releases from flood storage in Rafferty dam, Alameda dam, and storage in Boundary Dam in Saskatchewan, Canada, with releases from Lake Darling Dam in North Dakota to achieve 1-percent chance (100-year) flood protection at Minot, North Dakota. Releases from Saskatchewan reservoirs will be timed to meet a specific flow at the border (Sherwood gage). The flows at the border will be determined based on flows at Minot, North Dakota, and the level of Lake Darling. For the larger flood events, controlled releases will not exceed 4,000 cfs in the reach between the border near Sherwood and Lake Darling and 5,000 cfs between Lake Darling and Minot. For smaller flood events, flows in these reaches will be substantially less. For flood events up to 50 years, the following releases from Lake Darling will be made:

- Draw pool down to pre-flood target elevation as required for predicted 30-day flood volume.
- Follow target flow curve for peak flows at Minot, based on predicted 30-day flood volume.
- Release at target release rate, minimizing releases over 5,000 cfs.

- On or about 15 May (or when pool falls below 1600, whichever is later), cut back releases to 2,500 cfs or a lesser discharge depending on timing, reservoir stage, and projected inflow of the flood.

- By 1 June, cut back releases to 500 cfs until the conservation pool level at 1597 is reached.

For floods in the range of 50 to 100 years, the 5,000 cfs release will be extended beyond 15 May with a cutback to 500 cfs by 1 June and releases will be increased during February and March of the following year to achieve the required drawdown of flood storage. Lake Darling would be operated for flood control in a manner compatible with the migratory waterfowl refuge purpose of the reservoir.

RESPONSIBILITY OF OPERATION

Agreements which meet the requirements of Section 7, 1944 Flood Control Act, will be drawn up between Canada, the Secretary of the Army, and the U.S. Fish and Wildlife Service. The agreement between Canada and the Secretary of the Army will address the responsibility of the Saskatchewan Water Corporation's operation of Rafferty and Alameda dams in accordance with the operating plan in Appendix A. The agreement between the U.S. Fish and Wildlife Service will address the responsibility of operating Lake Darling Dam for the Corps of Engineers and the U.S. Fish and Wildlife Service. In general, it is understood that the Corps of Engineers would be responsible for the operation of Lake Darling Dam during flood operation in accordance with the operating plan in Appendix A and the U.S. Fish and Wildlife Service would have responsibility at all other times.

In accordance with the 1986 Water Resources Development Act, the Corps is directed to modify the Lake Darling project "for the purpose of effective operation of the project for flood control" and "to operate and maintain the project with such modifications in a manner compatible

with the migratory waterfowl-refuge purpose of the project." The Corps recognizes that the initial purpose of the Lake Darling Dam is to provide water supply to the Souris refuges and will operate the reservoir in such a manner as to minimize the impact of flood operation on this purpose. Spring drawdown for flood storage would be done only with certainty that the minimum inflow would be sufficient to restore the lake to the normal conservation pool level following spring runoff. The operating plan in Appendix A has been fully coordinated with the USFWS.

COST ESTIMATE

The cost estimate for the Souris River Basin project is summarized in two parts: cost of United States works and cost of Saskatchewan works. The cost estimate for U.S. works does not include sunk costs for the existing Minot channel and the Velva levee. Table 4 on the following page identifies the estimated costs (October 1985) of the U.S. project features and operating plan.

In accordance with the 1986 Water Resources Act, the cost of $41.1 million (October 1985) for Saskatchewan works was determined by an allocation of costs based on the proportionate use of Saskatchewan reservoirs for flood control in the United States and water supply in Canada. The United States contribution to Saskatchewan was determined by an allocation of costs based on the Use of Facilities method of analysis, providing net benefits to the United States, and discussions between Canada and the United States. The $41.1 million contribution to Saskatchewan is equivalent to the total benefit to the United States minus the cost for the United States features and minus a net benefit of $3.5 million. The $3.5 million net benefit is equivalent to the level of net benefits for the 4-foot raise of Lake Darling.

Table 4
Cost of Project Features and Operating Plan in United States

Project Feature	Project Costs ($1,000) October 1985 prices
FEDERAL	
Project Features	
Lake Darling Dam	2,500 (1)
Operation and Maintenance	1,000
USNWR - Downstream of Lake Darling Dam	2,455
USNWR - Upstream of Lake Darling Dam	0 (2)
JCSNWR	1,290
Manitoba Compensation	204 (3)
Hydrometeorological Instruments	156
Burlington - Minot Downstream	3,396
Sawyer Downstream	319
Rural Downstream (Lake Darling to Westhope)	4,500
Rural Downstream (Sherwood to Lake Darling)	0 (2)
Gassman Coulee/Hydrometeorological Data Network	260
Engineering and Design	1,800 (4)
Supervision and Administration	1,545 (4)
TOTAL FEDERAL	19,425 (5)
NON-FEDERAL	
Burlington - Minot Downstream	1,366
Sawyer Downstream	141
Rural Downstream	2,593 (5)
Mouse River Park (Renville County Park)	0 (5)
TOTAL NON-FEDERAL	4,100
TOTAL PROJECT COST	23,525 (6)

(1) Replacement of low-flow outlet structure.
(2) No cost has been identified at this time.
(3) Need/basis of this cost may change based on storages in Saskatchewan.
(4) Does not include sunk cost or costs for reconnaissance report, operating plan, agreement, or NEPA documentation. Does include costs for general design memorandum.
(5) Federal and non-Federal cost may increase, based on compensation/mitigation requirement of the operating channel between Sherwood and Lake Darling.
(6) Does not include Federal costs of $7,220,000 for dam safety and FWS measures which are items of work required to be accomplished together with the flood control work. Also, sunk costs of $5,580,000 for Velva improvements are not included in this amount.

United States Contribution to Saskatchewan (Costs in Millions of October 1985 Dollars)	
Total benefits to the United States	$68.1
Cost of the United States features	23.5
Total benefits minus U.S. features	44.6
Net benefits to the United States	3.5
Total U.S. contribution to Saskatchewan	$41.1

The analysis, in coordination with Saskatchewan, reviewed an array of alternative allocations of cost, and concluded that the most equitable allocation would be $41.1 million. This amount represents the upper limit of net benefits to the United States. Table 5 on page 35 summarizes the estimated Federal and non-Federal allocations of total project costs in the United States and Canada.

BENEFITS

Benefits are measured as the difference in flood damage between without project and with project conditions. Average annual flood reduction benefits for the Souris River Basin project are $5,857,400. Flood damage reduction benefits for urban, rural (which includes crop and other agricultural damage, and transportation) are given in Table 6. The Souris River Basin project is estimated to reduce average annual damages from $7,205,800 without the project to $1,348,400 with the project. As indicated on the table, this project is primarily an urban protection project with 94 percent of the benefits attributed to urban (83 percent for Minot) and 6 percent to rural areas.

Project Benefit Summary: Benefits for the project are summarized in Table 6.

Table 5
Cost of Project Features in Canada and the United States

Project Feature	Project Costs ($1,000) (1) October 1985 prices
FEDERAL	
Project Features	
Saskatchewan Storage, Operation, and Maintenance	36,700 (2)
Lake Darling Dam	2,500 (3)
Operation and Maintenance	1,000
USNWR - Downstream of Lake Darling Dam	2,455
USNWR - Upstream of Lake Darling Dam	0 (4)
JCSNWR	1,290
Manitoba Compensation	204 (5)
Hydrometeorological Instruments	156
Burlington - Minot Downstream	3,396
Sawyer Downstream	319
Rural Downstream (Lake Darling to Westhope)	4,500
Rural Downstream (Sherwood to Lake Darling)	0 (4)
Gassman Coulee	260
Engineering and Design	1,800
Supervision and Administration	1,545
TOTAL FEDERAL	56,125 (6)
NON-FEDERAL	
Saskatchewan Storage, Operation, and Maintenance	4,400 (2)(7)
Burlington - Minot Downstream	1,366
Sawyer Downstream	141
Rural Downstream	2,593 (6)
Mouse River Park (Renville County Park)	0 (6)
TOTAL NON-FEDERAL	8,500 (8)
TOTAL PROJECT COST	64,625

(1) Cost assumes Velva and Minot channel flood project has been completed and is operational.
(2) Payment to Saskatchewan for flood storage in Rafferty and Alameda Dams and their operation in conjunction with Boundary Dam for U.S. flood damage reduction.
(3) Replacement of low-flow outlet structure.
(4) No cost has been identified at this time.
(5) Need/basis of this cost may change based on storages in Saskatchewan.
(6) Federal and non-Federal cost may increase, based on compensation/mitigation requirement of the operating channel between Sherwood and Lake Darling. Does not include Minot's exchange rate/inflation protection.
(7) Represents 25 percent of project cost beyond the Lake Darling project. $63.4 million - $45.9 million = $17.5 million added cost. $17.5 million x 0.25 = $4.4 million.
(8) Does not include exchange rate or inflation protection agreed to by city of Minot.

Table 6 - Project Benefits

Category	Benefits[1]
Urban (Velva not included)	$5,520,700[2]
Rural	
Agriculture	30,000
Other Agriculture	47,700
Rural Residential	227,400
Transportation	31,600
Total	$5,857,400

(1) Benefits are expressed in October 1985 price levels and are annualized at 8-5/8 percent interest rate. The present worth of the total benefits is $68.1 million.

(2) Of this, $4,852,300 are at Minot.

NED BENEFITS

By design, the net benefits of the Souris River Basin project are intended to equal those of the Lake Darling project (4-foot raise). The cost to the United States for a flood control project which includes Canadian measures equals the cost to implement any features in the United States plus a contribution to Saskatchewan based on the benefits to the United States. The contribution to Saskatchewan ($41.1 million) is equivalent to the total project benefits realized by the United States minus the cost for the U.S. features minus a guaranteed net benefit of $3.5 million (present worth basis). In all cases, the net benefits equal $3.5 million. This is the amount of net benefits for the authorized raise of Lake Darling Dam and it was determined that any other project involving a Canadian feature should generate at least this level of net benefits. With regard to the definition of the NED project (maximization of net benefits), all projects, then, are equivalent.

Since all projects will generate the same level of net benefits, the project which is most complete is the one that provides the greatest level of flood protection. That project is the Souris River Basin project which would provide 100-year flood protection at Minot, North Dakota.

PROJECT SCHEDULE

Saskatchewan's draft project master schedule (January 1987) for the construction of Rafferty and Alameda dams is shown in Figure 2. Submission of the EIS has been delayed which in turn has delayed project approval to November 1987. Rafferty dam will be built over the summer of 1988 to 1990 instead of 1987 to 1988. The Saskatchewan Power Corporation has recommended that the last 2 years of construction of the Rafferty dam proceed simultaneously with the construction of Alameda dam.

The Corps draft master schedule (January 1987) for construction of common Lake Darling features is shown in Figure 3. Submission of the EIS is scheduled for August 1987 with the final record of decision signed in July 1988. It is recommended that the construction of the United States features parallel the construction of Saskatchewan features. This will allow project operation at the completion of construction of the Saskatchewan dams and take advantage of project flood control benefits as early as possible.

CONCLUSION

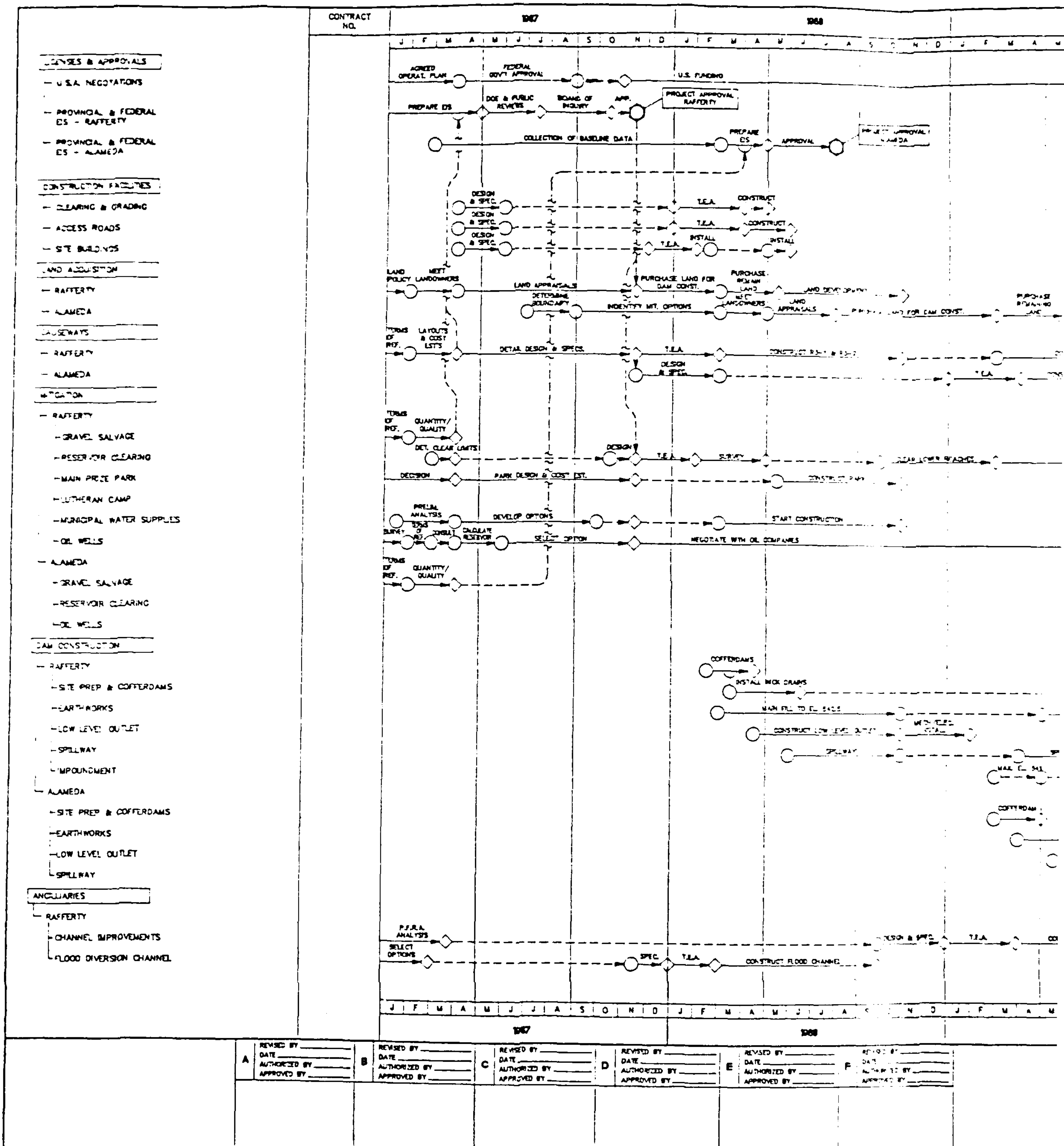
The Souris River Basin project is authorized in the Water Resources Development Act of 1986. The project will provide 100-year flood protection for the city of Minot, North Dakota, as compared to 25-year flood protection with the Lake Darling project. The project also will substantially reduce flood damages along urban and rural reaches of the Souris River between Sherwood, North Dakota and Westhope, North Dakota. Completed works include a 5,000 cfs channel at Minot, North Dakota, and a levee at Velva, North Dakota. Uncompleted work includes construction and purchase of flood storage at Alameda and Rafferty reservoirs in Saskatchewan, Canada; modification of Lake Darling Dam outlets for flood operation; levee improvements at Sawyer, Renville County Park, and six subdivisions downstream of Lake Darling Dam; rural improvements and the purchase of flowage easements; mitigation measures; development of a flood warning systems; and compensation to Manitoba for altered return flows. Project feasibility is heavily dependent upon the United States' ability to meet the Province of Saskatchewan's construction schedule and cost-sharing requirements.

RECOMMENDATION

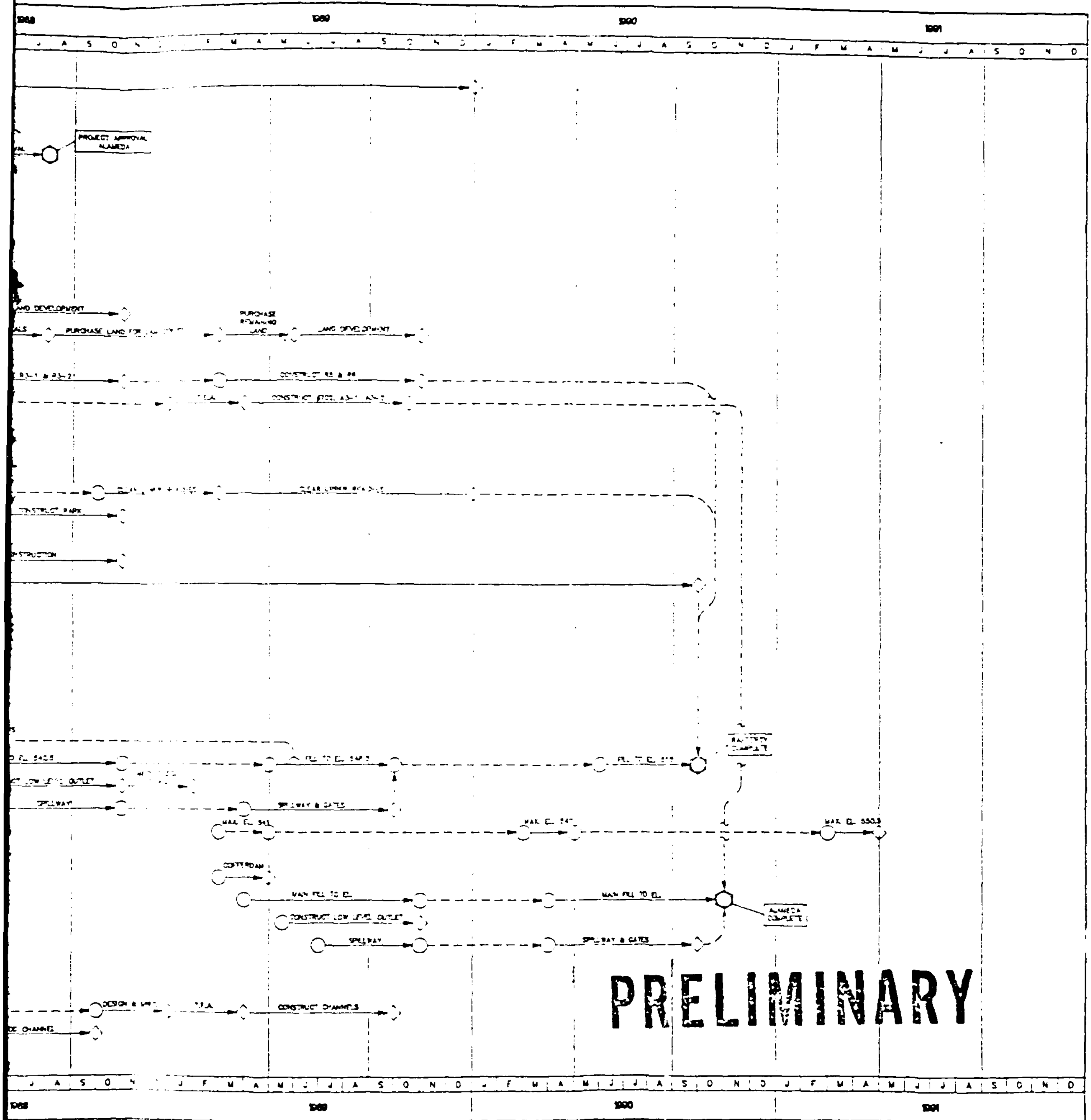
It is my determination that an agreement between the United States and Governments in Canada can be consummated for payment to Canada for construction of United States flood storage at Rafferty and Alameda reservoirs in Saskatchewan, Canada, based on the study of the Souris River Basin project in cooperation with Governments in Canada and the local sponsor. I recommend that the autnorized Souris River Basin project be implemented as a Federal project. Funds would be used to participate in financing the storage in Canada for flood control in North Dakota to a maximum contribution of $26,700,000 in the event the Rafferty reservoir is constructed in Canada and to a maximum contribution of $41,100,000 in the event both Rafferty and Alameda reservoirs are constructed in Canada and to finance modifications to the

Lake Darling project for flood control in North Dakota not to exceed a total Federal cost of $69,100,000. All costs shown are in October [illegible] United States dollars.

In view of project authorization and current commitments among the Administration, Congress, State Department, and Governments in Canada, it would be appropriate to pursue, as expeditiously as possible, the completion of the enclosed EIS and the cost sharing and technical agreements with Canada, to meet Saskatchewan's high priority schedule for construction of storage in Rafferty and Alameda dams.



Saskatchewan's Draft Project Master Schedule for the ...truction of Raf...

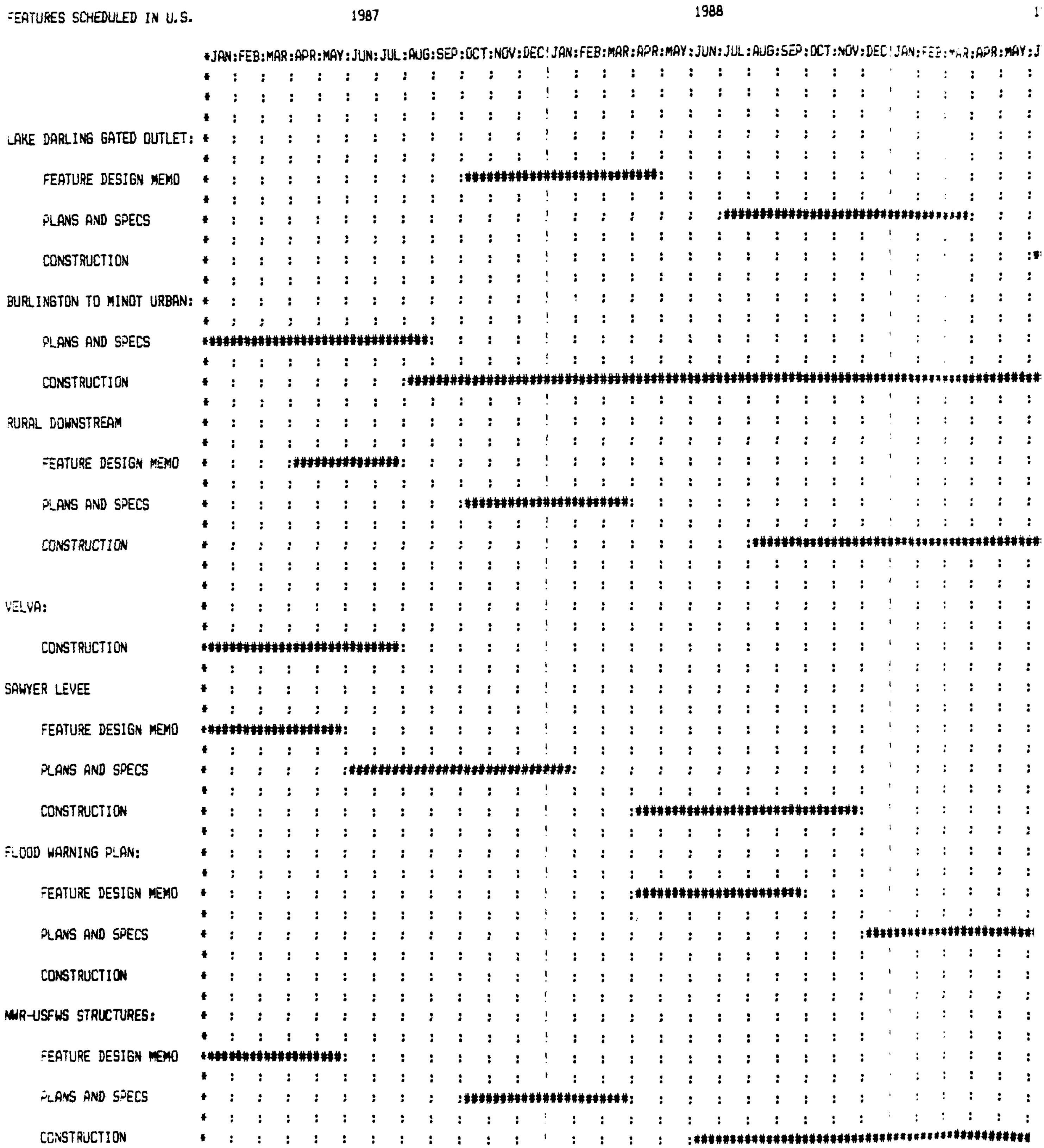


APPROVED BY	DATE	SASKATCHEWAN POWER CORPORATION
		PROJECT MASTER SCHEDULE RAFFERY / ALAMEDA DAMS

...the Construction of Rafferty and Alameda Dams (January 19...

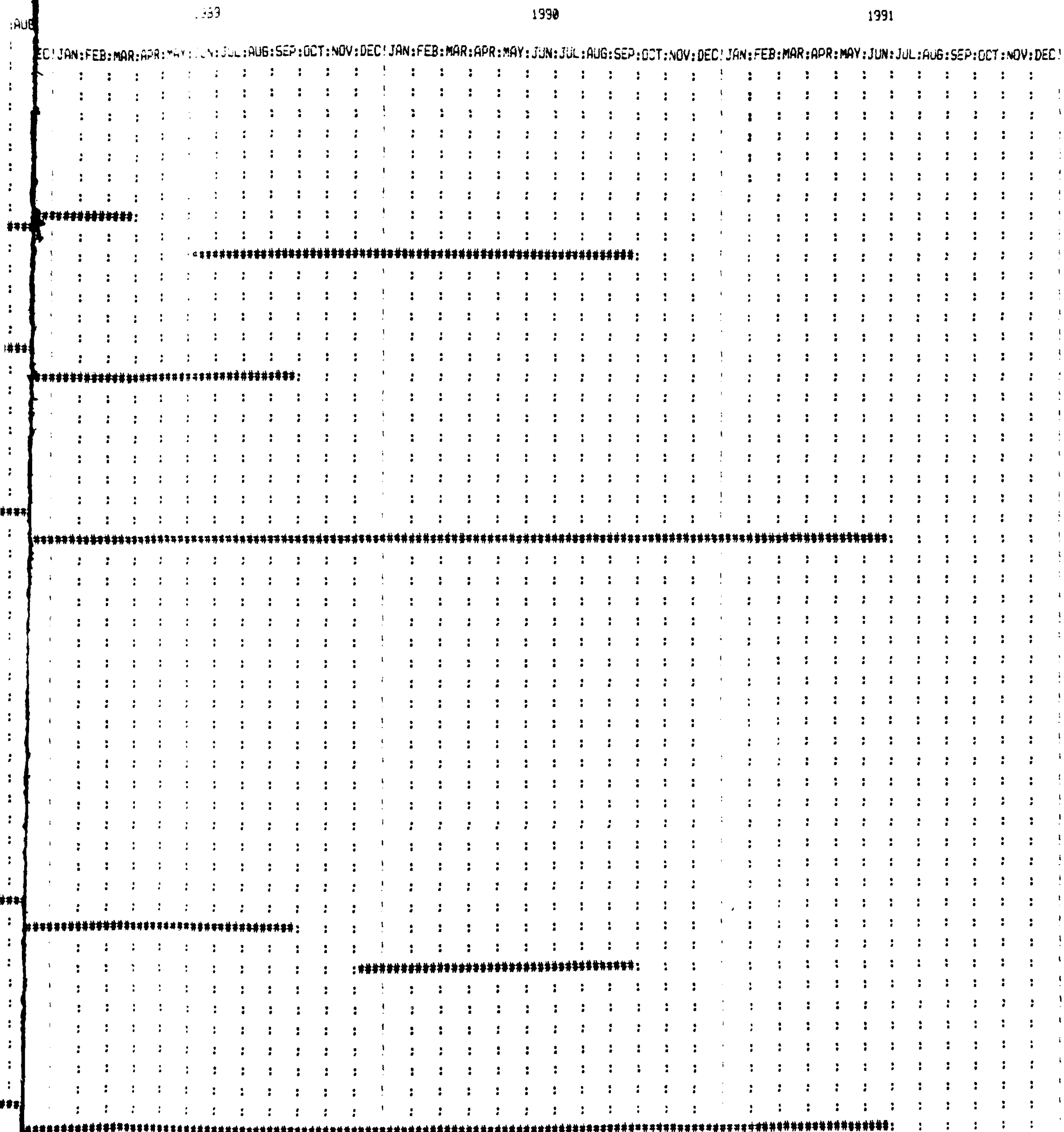
FIGURE 2

SOURIS RIVER BASIN PROJECT: U.S. WORK



Corps of Engineers Draft Master Schedule f[illegible]uction

SOURIS RIVER BASIN PROJECT: U.S. WORK



r Construction ... Lake Darling Features (January 19

FIGURE 3

APPENDIX A

DRAFT OPERATING PLAN

FOR

RAFFERTY, ALAMEDA, BOUNDARY, AND LAKE DARLING RESERVOIRS

Revised 04 Sept 1987

DRAFT
OPERATING PLAN FOR
RAFFERTY, ALAMEDA, BOUNDARY, AND LAKE DARLING RESERVOIRS
FOR FLOOD CONTROL

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INTRODUCTION

Purpose: This draft operating plan was developed to provide the basis for an agreement in principle on the operation of the Souris Basin Project for flood control and evaporation sharing. The plan also provides the framework for completing individual project specific reservoir regulation manuals.

Scope: The draft operating plan is limited to the operation of the Souris Basin Project in the Souris River Basin in Saskatchewan, Canada, and North Dakota, United States of America.

Objectives: The objectives of the operating plan are:

-To provide 1-percent (100-year) flood protection at Minot, North Dakota;

-To provide flood protection to urban and rural areas downstream from Rafferty, Alameda, and Lake Darling dams;

-To ensure, to the extent possible, that the water supply benefits for the Souris Basin Project and Lake Darling are not compromised; and,

-To provide a basis for the sharing of the natural flows of the Souris River according to the 1959 Interim Measures and consideration of evaporation losses for Rafferty and Alameda Reservoirs.

Document: This document includes information on the operation of the Souris Basin Project to include: existing and expanded hydrometeorological data network, data on the physical characteristics of the dams and reservoirs, rules for flood and non-flood operation, and procedures for communication and exchange of information. This draft operating plan establishes guidelines for operation. It will be necessary for agencies directly responsible for the daily operation of each project to develop detailed reservoir regulation manuals. The draft operating plan was developed based on computer simulations of floods having temporal and spatial characteristics of those actually experienced in floods of 1969, 1974, 1975, 1976, 1979, and 1982. It is recognized that this draft operating plan may not cover all possible flood circumstances, and it may be necessary for the agencies directly responsible for the operation of the project to jointly agree on changes to the draft operating plan that will better achieve its objectives. A basin map is shown on figure A-v.

Forecasting: The ability to provide increased flood protection (including the ability to limit flows at Minot to 5,000 cfs for floods up to the 1-percent event) while optimizing the water supply potential of the Souris River Basin is dependent upon the accuracy of the estimates of runoff provided to the agencies responsible for the daily operation of each project, (Section 4.3.1). The runoff estimates used in this operating plan are: runoff volume, 30-day; runoff volume, 90-day; Sherwood uncontrolled runoff volume; and runoff volume, 90-percent, 90-day. Data used to develop the runoff estimates are gathered by Environment Canada and Saskachewan Water Corporation in Canada and the National Weather Service in the United States. As noted in Section 2.4, new estimating techniques will be developed by the Corps of Engineers and the Saskachewan Water Corporation. If the new estimating techniques cannot be developed for the four items listed above, (with sufficient accuracy to meet the dual objectives of flood control and water conservation), then the operating plan will be modified to use existing methods of estimating runoff.

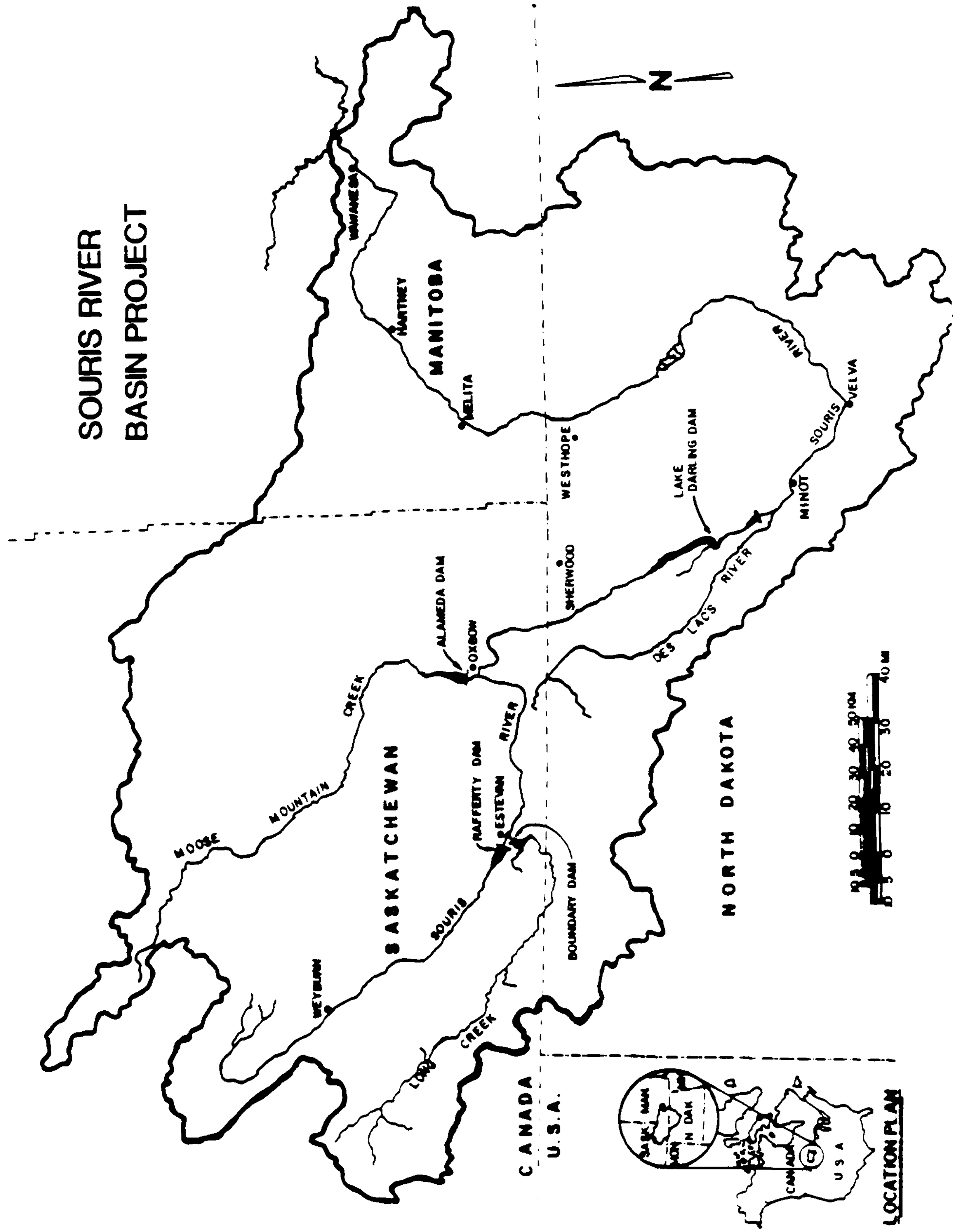

SOURIS RIVER
BASIN PROJECT
N
WAWANESA
HARTNEY
MANITOBA
MELITA
WESTHOPE
LAKE DARLING DAM
SOURIS
RIVER
VELVA
MINOT
SHERWOOD
ALAMEDA DAM
OXBOW
DES LACS RIVER
MOOSE MOUNTAIN CREEK
SASKATCHEWAN
RAFFERTY DAM
ESTEVAN
RIVER
SOURIS
BOUNDARY DAM
NORTH DAKOTA
WEYBURN
LONG CREEK
CANADA
U.S.A.
LOCATION PLAN

FIGURE A-1

1.0 TERMINOLOGY

1.1 Glossary of Terms and Definitions

Alameda Dam	- The dam which will be constructed at a location on the Moose Mountain Creek approximately 15 kilometres upstream in a northwesterly direction from the town of Oxbow, in the Province of Saskatchewan.
Authority	- The Souris Basin Development Authority.
Bankfull capacity	- The maximum flow that a given watercourse can convey in a specified reach without the water level rising above the level of either bank.
Boundary Dam	- A presently existing structure located on Long Creek approximately 7 kilometres in a southwesterly direction from the City of Estevan, in the Province of Saskatchewan.
Boundary Diversion Channel	- A channel that will be constructed with a maximum capacity of 60 m^3/s (2,100 cfs) to allow conveyance of water from Boundary Reservoir to Rafferty Reservoir
Canadian reservoirs	- A collective term for Rafferty Reservoir, Boundary Reservoir and Alameda Reservoir.
Control point	- A streamflow gaging station or dam which is used to develop operating decisions for Rafferty, Alameda and Boundary Reservoirs, and Lake Darling.
Controlled volume	- The volume of runoff that can be controlled by using available flood control storage.
Corps	- The United States Army Corps of Engineers.
Drawdown	- The physical act of lowering the pool level of a reservoir through controlled releases.
Estimate	- A value based on the best judgment of qualified personnel using all available data.
Flood control storage	- The volume set aside below the maximum allowable water level in a reservoir to store flood event runoff.
Full Supply Level (FSL)	- The maximum elevation that the reservoir pool is allowed to attain when operations are not directed at achieving flood control benefits.

International apportionment	- The amount of water that must be passed via the Souris River to North Dakota at Sherwood in a given year based on the 1909 Boundary Waters Treaty and 1959 Interim Measures.
Lake Darling Dam	- A presently existing structure located on the Mouse River (Souris River) approximately 25 kilometres in a northwesterly direction from the city of Minot in the State of North Dakota.
Local flow	- The runoff that occurs between two given locations.
Maximum allowable flood level	- The highest level a reservoir pool is allowed to reach while storing water for flood control purposes. When a reservoir pool reaches this level, any flows into the reservoir must be spilled.
Maximum level prior to spring runoff	- The pool level which must not be exceeded prior to the spring runoff, regardless of the predicted volume of runoff.
Minimum supply level	- The lowest pool level at which water can be released from a reservoir (invert of conduits).
Natural flow	- The volume of runoff determined by the International Souris River Board of Control.
1-percent flood (100-year flood)	- A runoff event which is estimated to generate a total 30-day continuous flow volume equal to 721,000 cubic decametres (584,500 acre-feet) as determined at Sherwood based on data recorded at that station prior to 1986.
Pool level	- The static water surface elevation of a reservoir.
Rafferty Dam	- The dam which will be constructed at a location on the Souris River approximately 5 kilometres upstream in a northwesterly direction from the city of Estevan, in the Province of Saskatchewan.
Releases	- The controlled discharge of water from a reservoir other than spills.

Reservoir Regulation Manual	- A document which is to be used as a guide by the responsible agency in the day to day operation of a reservoir. The manual shall discuss the following topics: description of the project, history of the project, watershed characteristics, data collection and communication networks, hydrologic forecasts, the water control plan, and water control management.
Runoff	- The flow of water in a watercourse in response to rainfall and/or snowmelt.
Runoff volume, 30-day (30-day volume)	- Maximum 30-consecutive-day runoff volume that occurs in any water year.
Runoff volume, 90-day (90-day volume)	- Maximum 90-consecutive-day runoff volume that occurs in any water year.
Runoff volume, 90-percent, 90-day	- The estimated 90-day volume of unregulated runoff with a 90-percent probability of being equalled or exceeded by the actual runoff.
Saskatchewan works	- The works in Saskatchewan, Canada, to include Rafferty Dam, Alameda Dam, and Boundary to Rafferty Diversion Channel.
Sherwood	- The International gaging station, number 05114000, latitude 48:59:24, longitude 101:57:28, on the Souris River, 0.8 mile downstream of the International boundary.
Sherwood uncontrolled runoff volume	- The uncontrolled volume from the Canadian Reservoirs, if any, and the local flow between the Canadian Reservoirs and Sherwood.
Souris Basin Project (Project)	- The development and operation of the Saskatchewan works in Canada; the operation of the existing Boundary Reservoir in Saskatchewan and the operation of the existing Lake Darling Reservoir in North Dakota in the United States for flood control.
Spills	- The uncontrolled discharge of water from a reservoir.
Target drawdown level	- A pool level to which a reservoir should be lowered in response to estimated spring runoff so that the desired level of flood protection will be provided.

Target flow	- The instantaneous flow at a given location that should not be exceeded during a given flood event as a result of releases from a reservoir or reservoirs.
Temporary target flow	- A target flow at Sherwood that has been modified to take into account available storage in Lake Darling.
Uncontrolled volume	- The volume of runoff that can not be controlled by the available flood control storage.
Unregulated flow at Sherwood	- That flow that would occur at Sherwood if Rafferty and Alameda were not in place.
Water year	- October 1 to September 30.

1.2 Abbreviations

Following is a list of abbreviations used in this agreement:

ac-ft	-	acre-feet
cfs	-	cubic feet per second
dam^3	-	cubic decametre
ft	-	feet
m	-	metre
m^3/s	-	cubic metres per second
km	-	kilometre

1.3 Conversion Factors

Different units of measure are being used in Canada and the United States. Therefore it is necessary to setforth the method by which these different units will be used within this appendix. When discussing those features in Canada, metric units will be given first followed by the English units in parentheses. When discussing features in the United States, English units will be given first followed by metric units in parentheses.

The following table may be used to convert measurements in the English (United States) system of units to the SI or metric (Canadian) system of units.

Multiply English Units	by	To obtain SI Units
	Length	
inch (in)	25.4	millimetre (mm)
foot (ft)	0.3048	metre (m)
mile (mi)	1.609344	kilometre (km)
	Area	
square mile (mi^2)	2.590	square kilometre (km^2)
acre (ac)	4051.09	square metre (m)
	Flow	
cubic foot per second (cfs)	0.02831685	cubic metre per second (m^3/s)
	Volume	
acre-foot (ac-ft)	1.233482	cubic decametre (dam^3)
	Velocity	
foot per second (ft/s)	0.3048	metre per second (m/s)
	Slope	
foot per mile (ft/mi)	0.1894	metre per kilometre (m/km)

1 ha = 10,000 m^2 ==> ha x 2.46848 = acre

1 dam = 1,000 m^3 ==> dam^3 x 0.811 = ac-ft

2.0 HYDROMETEOROLOGICAL DATA NETWORK

2.1 General

The collection and distribution of hydrologic and meteorological data in the Souris River basin involves government agencies in the United States and Canada. The data collection network is vital to the successful operation of Rafferty, Boundary, and Alameda Reservoirs in Canada and Lake Darling in the United States. The network may be modified from time to time. The applicable existing data collection network consists of the following agencies.

Canada

In Canada, the Water Survey of Canada is responsible for maintaining and operating a network of hydrometric stations to record streamflow and water levels while the Atmospheric Environment Service maintains and operates a network of meteorological stations. Both the Water Survey of Canada and the Atmospheric Environment Service are part of Environment Canada, a Federal government agency. In addition, the Saskatchewan Water Corporation, a Provincial crown corporation, operates a number of snow course stations in the basin. The purpose of the snow course measurements is to provide additional data for estimating spring runoff.

United States

In the United States, the U.S. Geological Survey is responsible for maintaining and operating a network of hydrometric stations to record streamflow and water levels, while the National Weather Service operates and maintains a network of meteorological stations. Both organizations are Federal agencies. In addition to the meteorological stations, the National Weather Service undertakes aerial gamma surveys to provide additional snow data for estimating spring runoff.

The networks operated by these agencies are shown on the map in figure A-2 and are described in the following section.

2.2 Station Networks

The existing hydrometric station networks for Canada and for the United States are shown on Table 2.1 and on Table 2.2, respectively.

The existing meteorological station networks are shown on Table 2.3 for Canada and on Table 2.4 for the United States.

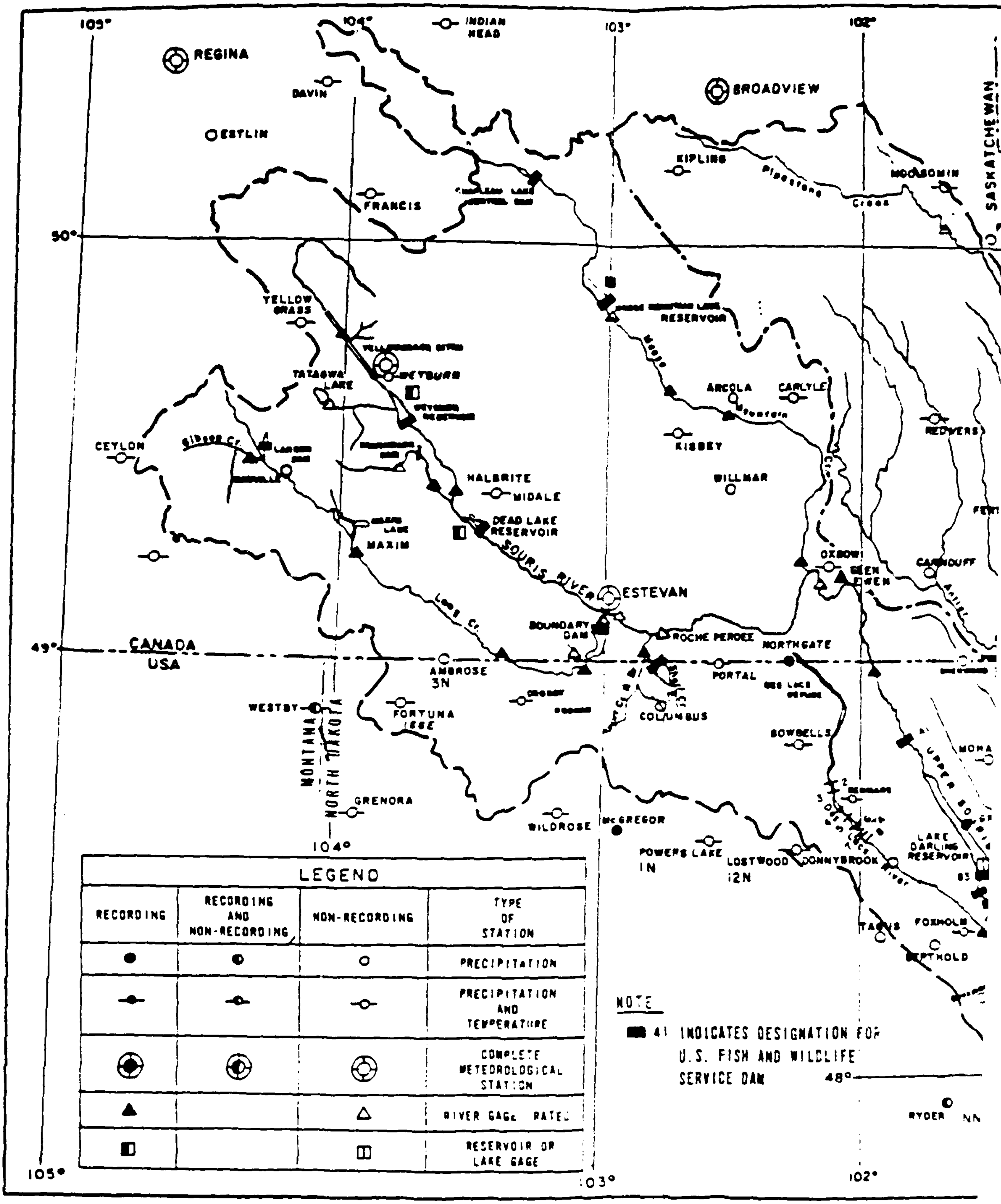
2.3 Additional Stations

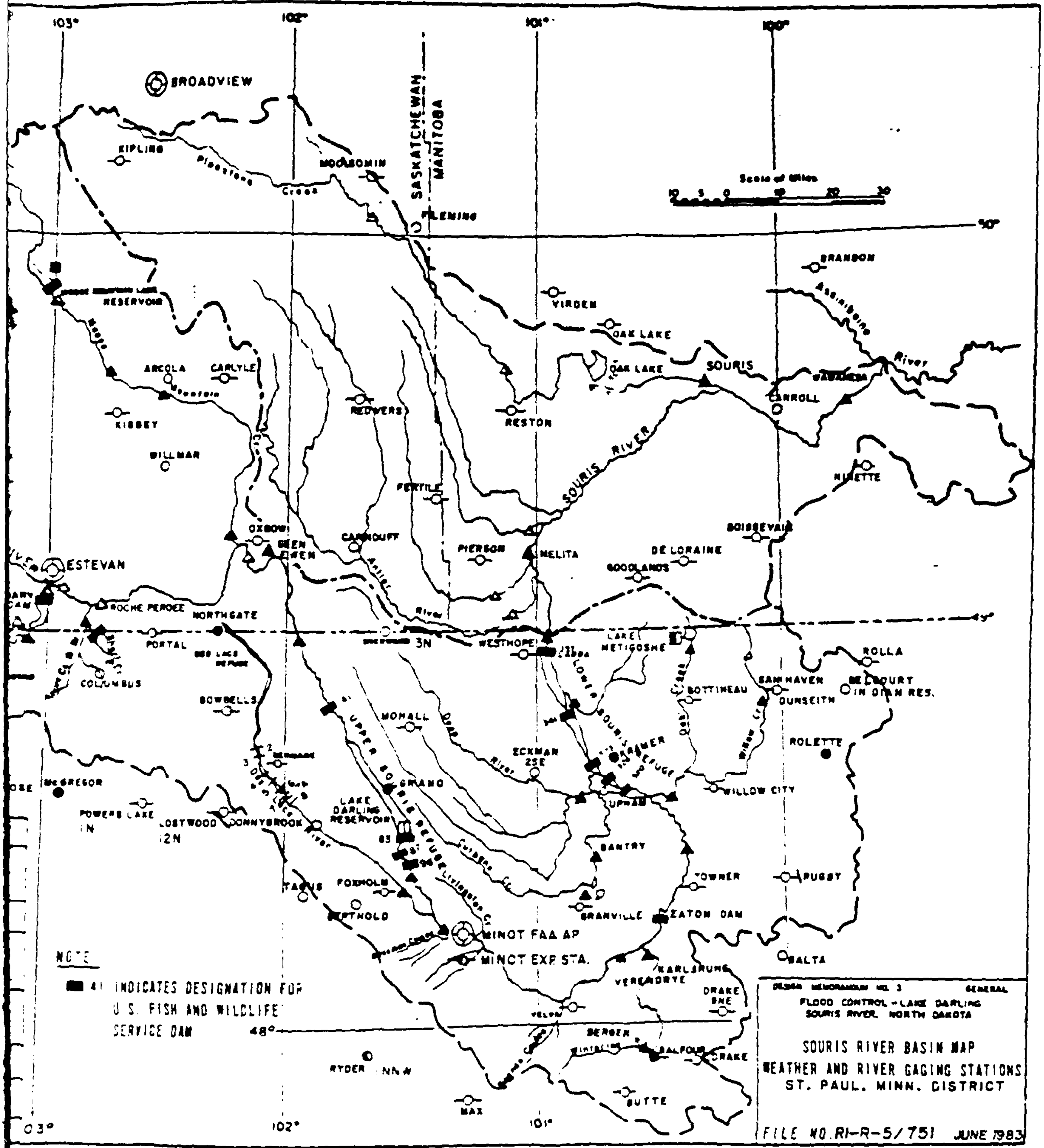
Gages and methods will be established to measure inflow, pool levels, and downstream flows for Rafferty Reservoir and for Alameda Reservoir. Additional gaging stations may be added to ensure the appropriate operation of the project.

2.4 Data Collection, Estimating, and Coordination

Close coordination and exchange of data will be maintained by operating agencies to facilitate Project operation, with particular reference to pre-flood drawdown. Other items will be detailed in the Reservoir Operation Manual

Estimating techniques will be developed by representatives of U.S. Army Corps of Engineers and Saskatchewan Water Corporation. These estimating techniques will be discussed in the Reservoir Regulation Manuals, which will be written at a later date.


105°
104°
103°
102°
50°
49°
48°
INDIAN HEAD
REGINA
BROADVIEW
DAVIN
ESTLIN
KIPLING
FRANCIS
MOOSOMIN
Pipestone Creek
SASKATCHEWAN
YELLOW GRASS
RESERVOIR
WEYBURN
TATAGWA LAKE
ARCOLA
CARLYLE
REDVERS
CEYLON
Gibson Cr.
KISBEY
HALBRITE
MIDALE
WILLMAR
DEAD LAKE RESERVOIR
MAXIM
SOURIS RIVER
OXBOW
GLEN EWEN
CARNDUFF
ESTEVAN
Long Cr.
BOUNDARY DAM
ROCHE PERCEE
NORTHGATE
CANADA
USA
AMBROSE 3N
PORTAL
WESTBY
FORTUNA 1SSE
COLUMBUS
BOWBELLS
MONTANA
NORTH DAKOTA
UPPER SOURIS
GRENORA
WILDROSE
McGREGOR
POWERS LAKE 1N
LOSTWOOD 12N
DONNYBROOK
LAKE DARLING RESERVOIR
TAGUS
FOXHOLM
BERTHOLD
RYDER
LEGEND
RECORDING
RECORDING AND NON-RECORDING
NON-RECORDING
TYPE OF STATION
PRECIPITATION
PRECIPITATION AND TEMPERATURE
COMPLETE METEOROLOGICAL STATION
RIVER GAGE RATED
RESERVOIR OR LAKE GAGE
NOTE
41 INDICATES DESIGNATION FOR U.S. FISH AND WILDLIFE SERVICE DAM



BROADVIEW
SASKATCHEWAN
MANITOBA
KIPLING
MOOSOMIN
FLEMING
Scale of Miles
BRANDON
VIRDEN
OAK LAKE
SOURIS
Assiniboine River
CARROLL
ARCOLA
CARLYLE
KISBEY
REDVERS
RESTON
SOURIS RIVER
WILLMAR
NINETTE
FERTILE
OXBOW
GLEN EWEN
CARNDUFF
PIERSON
MELITA
DE LORAINE
BOISSEVAIN
GOODLANDS
ESTEVAN
ROCHE PERCEE
NORTHGATE
PORTAL
WESTHOPE
LAKE METIGOSHE
ROLLA
COLUMBUS
SAN HAVEN
DUNSEITH
BELCOURT IN DIAN RES.
BOTTINEAU
BOWBELLS
MOHALL
UPPER SOURIS REFUGE
LOWER SOURIS REFUGE
ECKMAN 2SE
ROLETTE
McGREGOR
GRANO
WILLOW CITY
UPHAM
POWERS LAKE
LOSTWOOD
DONNYBROOK
LAKE DARLING RESERVOIR
BANTRY
TOWNER
RUGBY
FOXHOLM
BERTHOLD
GRANVILLE
EATON DAM
MINOT FAA AP
MINOT EXP STA.
BALTA
KARLSRUHE
VERENDRYE
DRAKE 9NE
VELVA
BERGEN
BALFOUR
DRAKE
RYDER NNW
MAX
BUTTE
NOTE
41 INDICATES DESIGNATION FOR U.S. FISH AND WILDLIFE SERVICE DAM
DESIGN MEMORANDUM NO. 3 GENERAL
FLOOD CONTROL - LAKE DARLING
SOURIS RIVER, NORTH DAKOTA
SOURIS RIVER BASIN MAP
WEATHER AND RIVER GAGING STATIONS
ST. PAUL, MINN. DISTRICT
FILE NO. RI-R-5/751 JUNE 1983

FIGURE A-2

TABLE 2.1

HYDROMETRIC STATION NETWORK FOR SOURIS BASIN IN SASKATCHEWAN

Station No.	Station Name	Location		Type
		Latitude	Longitude	
05NA003	Long Creek at Western Crossing	49 00 01	103 21 08	Flow; auto recorder; telemark
05NA004	Long Creek near Maxim	49 15 32	103 57 22	Flow; auto recorder; seasonal
05NA005	Gibson Creek near Radville	49 29 02	104 20 11	Flow; auto recorder; seasonal
05NA006	Larson Reservoir near Radville	49 28 30	104 16 50	Water level; auto recorder
05NB001	Long Creek near Estevan	49 06 15	103 00 48	Flow; auto recorder
05NB009	Souris River nr. Roche Percee	49 04 34	102 45 53	Flow; auto recorder
05NB011	Yellow Grass ditch near Yellow Grass	49 47 11	104 02 16	Flow; auto recorder; seasonal
05NB012	Boundary Res. near Estevan	49 05 49	103 01 28	Water level; auto recorder
05NB014	Jewel Creek nr. Goodwater	49 23 10	103 42 42	Flow; auto recorder; seasonal
05NB015	Roughbark Res. near Weyburn	49 30 08	103 43 07	Water level; auto recorder
05NB017	Souris River nr. Halbrite	49 29 37	103 39 44	Flow; auto recorder; seasonal
05NB018	Tatagwa Lake Dr. near Weyburn	49 35 58	103 56 50	Flow; auto recorder; seasonal
05NB020	Nickle Lake nr. Weyburn	49 34 32	103 46 08	Water level; auto recorder
05NB021	Short Creek nr. Roche Percee	49 01 52	102 50 57	Flow; auto recorder
05NB022	Dead Lake Res. near Midale	49 17 23	103 26 40	Water level; auto recorder
05NB025	Souris River near Lewvan	49 58 37	104 04 33	Flow; auto recorder; seasonal

TABLE 2.1 (cont.)

HYDROMETRIC STATION NETWORK FOR SOURIS BASIN IN SASKATCHEWAN

Station No.	Station Name	Location Latitude	Location Longitude	Type
05NB029	Dead Lake - Souris River	49 17 23	103 26 40	Water level; auto recorder
05NB030	Souris River near McTaggart	49 46 10	104 00 54	Flow; auto recorder; seasonal
05NB031	Souris River near Bechard	49 59 20	104 11 24	Flow; auto recorder; seasonal
05NC001	Moose Mountain Creek below Moose Mountain Lake	49 52 23	103 00 54	Flow; auto recorder; seasonal
05NC002	Moose Mountain Reservoir	49 53 29	103 01 58	Water level; auto recorder
05ND001	Souris River nr. Glen Ewen	49 11 01	102 01 42	Flow; auto recorder
05ND004	Moose Mountain Creek nr. Oxbow	49 13 58	102 13 41	Flow; auto recorder; seasonal
05NF006	Lightning Creek near Carnduff	49 13 17	101 43 06	Flow; auto recorder; seasonal
05NF010	Antler River near Wauchope	49 35 03	101 50 58	Flow; auto recorder; seasonal
05NF013	Gainsborough Ck. nr. Starthoaks	49 24 51	101 31 36	Flow; auto recorder; seasonal
24-131	Souris River at #18 Highway	49 07 42	103 01 17	Flow; manual recorder; Extreme flow only
24-132	Souris River at #47 Highway	49 07 11	102 59 32	Flow; manual recorder; Extreme flow only
24-133	Souris River at Oxbow	49 13 04	102 11 08	Flow; manual recorder; Extreme flow only
	Souris River at Pulfer's Farm	INFORMATION NOT AVAILABLE		

TABLE 2.2
HYDROMETRIC STATION NETWORK FOR SOURIS BASIN IN NORTH DAKOTA

Station No.	Station Name	Location Latitude	Location Longitude	Type
05114000	Souris River nr. Sherwood N.D.	48 59 24	101 57 28	Flow; auto recorder; telemark
05115500	Lake Darling near Foxholm	48 27 27	101 35 14	Water level; auto recorder
05116000	Souris River near Foxholm	48 22 20	101 30 18	Flow; auto recorder; telemark
05116500	Des Lac River near Foxholm	48 22 14	101 34 11	Flow; auto recorder
05117500	Souris River above Minot	48 14 46	101 22 15	Flow; auto recorder; telemark
05120000	Souris River near Verendrye	48 09 35	100 43 45	Flow; auto recorder
05120500	Wintering River near Karlsruhe	48 10 14	100 32 20	Flow; auto recorder
05122000	Souris River near Bantry	48 30 20	100 26 04	Flow; auto recorder; telemark
05123000	Lake Metigoshe near Bottineau	48 59 05	100 20 52	Water level; auto recorder
05123400	Willow River near Willow City	48 35 20	100 26 30	Flow; auto recorder
05123500	Deep River near Upham	48 35 03	100 51 44	Flow; auto recorder; telemark
05123900	Boundary Creek near Landa	48 48 46	100 51 46	Flow; auto recorder
05124000	Souris River near Westhope	48 59 47	100 57 29	Flow; auto recorder

TABLE 2.3
METEOROLOGICAL STATION NETWORK FOR SOURIS BASIN IN SASKATCHEWAN

Station Name	Station	Location Lat	Location Long	TE	PR	HW	RR	ST	EV	SU	SS	NS	WS
Alameda		49 24	102 16								X		
Amulet	4010150	49 37	104 44	X	X								
Arcola COA	4010240	49 38	102 32		X								
Bechard	4010540	50 03	104 13	X	X								
Broadview	4010879	50 23	102 35	X	X	X	X	X	X	X	X	X	
Carlyle	4011160	49 38	102 17	X	X								
Carlyle		49 39	102 16								X		
Carlyle C-7		49 39	102 20								X		
Carnduff	4011250	49 13	101 45		X								
Ceylon	4011441	49 24	104 39	X	X								
Davin	4012162	50 24	104 11		X								
Davin	4012165	50 22	104 09		X								
Davin	4012166	50 23	104 10	X	X		X		X				
Estevan		49 05	102 59								X		
Estevan A	4012400	49 04	103 00	X	X	X	X	X	X	X	X	X	
Estevan C-9		49 08	102 56								X		
Fertile	4012485	49 20	101 27	X	X								
Fleming S.	4012525	50 02	101 35		X								
Francis	4012720	50 07	103 55	X	X								
Frobisher		49 13	102 09								X		
Gainsborough	4012790	49 18	101 32		X								
Glenavon		50 12	103 08								X		
Handsworth	4013098	48 51	102 52	X	X								
Handsworth		49 53	103 02								X		
Heward	4013221	49 45	103 09	X	X								
Hitchcock		49 15	103 10								X		
Hume		49 40	103 37								X		
Indian Head CDA	4013480	50 32	103 40	X	X			X				X	
Indian Head PFRA	4013490	50 31	103 41	X	X			X	X	X			X
Kipling	4014040	50 12	102 44	X	X								
Kisbey		49 40	102 45								X		

*TE - Temperature
PR - Precipitation
HW - Hourly Weather
RR - Rate of Rainfall
ST - Soil Temperature
EV - Evaporation
SU - Sunshine
SS - Snow Survey
NS - Nipher Snow Measurements
WS - Windspeed

TABLE 2.3 (cont.)
METEOROLOGICAL STATION NETWORK FOR SOURIS BASIN IN SASKATCHEWAN

Station Name	Station	Location Lat	Location Long	TE	PR	HW	RR	ST	EV	SU	SS	NS	WS
Macoun	4014870	49 14	103 14		X								
Maryfield	4015045	49 50	101 32	X	X								
Maxim		49 19	103 57								X		
Midale	4015160	49 24	103 25	X	X								
Moose Mountain Reservoir	4015344	49 53	103 02	X	X				X				
Moosomin	4015360	50 09	101 40	X	X								
Neptune		49 22	104 06								X		
Neptune S.		49 19	104 02								X		
Noonan N.D.		48 57	103 03								X		
Odessa	4015648	50 20	103 41	X	X								
Oungre		49 09	103 45								X		
Oxbow	4015800	49 19	102 07	X	X								
Oxbow		49 14	102 07								X		
Radville CDA	4016400	49 30	104 17			X							
Redvers	4016522	49 32	101 42	X	X								
Torquay	4018105	49 05	103 30		X								
Trossachs N.E.		49 36	104 11								X		
Trossachs S.		49 34	104 17								X		
Wapella - Newfinland	4018508	50 27	101 56	X	X								
Wawota	4018678	49 56	101 58	X	X								
Weyburn	4018760	49 39	103 50	X	X			X	X	X			X
Weyburn		49 40	103 53								X		
Weyburn 2	4018762	49 40	103 51		X								
Willmar	4018960	49 25	102 30		X								
Yellow Grass	4019040	49 48	104 10	X	X								

*TE - Temperature
PR - Precipitation
HW - Hourly Weather
RR - Rate of Rainfall
ST - Soil Temperature
EV - Evaporation
SU - Sunshine
SS - Snow Survey
NS - Nipher Snow Measurements
WS - Windspeed

TABLE 2.4

METEOROLOGICAL STATION NETWORK FOR SOURIS BASIN IN NORTH DAKOTA

Station Name	Location Lat		Location Long		Observing Programs * PR	TE	SS	HW	SU	EV
Ambrose	49	00	103	28	X		X			
Belcourt	48	50	99	45	X	X	X			
Berthold	48	19	101	44	X		X			
Bottineau	48	50	100	27	X	X	X			
Bowbells	48	48	102	15	X	X	X			
Butte	47	50	100	40	X	X	X			
Columbus	48	55	102	50	X		X			
Crosby	48	54	103	18	X	X	X			
Drake 8NE	48	02	100	17	X	X	X			
Fortuna 1W	48	55	103	49	X	X	X			
Foxholm 7N	48	20	101	33	X	X	X			
Granville	48	16	100	51	X	X	X			
Kenmare	48	40	102	06	X	X	X			
Lake Metigoshe	48	59	100	21	X		X			
Max	47	49	101	18	X	X	X			
Minot FAA	48	16	101	17	X	X	X	X		
Minot Exp. St.	48	11	101	18	X	X	X		X	X
Mohall	48	48	101	31	X	X	X			
Rolla 3NW	48	54	99	40	X	X	X			
Rugby	48	21	100	00	X	X	X			
Sherwood 3N	49	00	101	38	X		X			
Tagus	48	20	101	56	X		X			
Tower NE	48	21	100	24	X	X	X			
Upham 3N	48	37	100	44	X	X	X			
Westhope	48	55	101	22	X	X	X			

*PR - Precipitation
TE - Temperature
SS - Snow Survey
HW - Hourly Weather
SU - Sunshine
EV - Evaporation

3.0 CONTROL POINTS

3.1 Rafferty Dam

The relevant data for this control point are presented on Tables 3.1 and 3.2. The storage-surface area-elevation curves are shown on Plate A-7. In the event of a discrepancy, the tabulated values will be used.

Table 3.1
Data for Reservoirs

Description	Elevation	Total Storage
Rafferty Reservoir		
Maximum allowable flood level	554.00 m (1817.59 ft)	633,000 dam^3 (513,000 ac-ft)
Full supply level	550.50 m (1806.10 ft)	439,600 dam^3 (356,400 ac-ft)
Normal level prior to spring runoff	549.50 m (1802.82 ft)	394,000 dam^3 (319,000 ac-ft)
Minimum supply level	537.50 m (1763.45 ft)	13,000 dam^3 (10,000 ac-ft)
Boundary Reservoir		
Full supply level	560.83 m (1840.00 ft)	61,500 dam^3 (49,800 ac-ft)
Minimum supply level	553.21 m (1815.00 ft)	24,900 dam^3 (20,800 ac-ft)
Alameda Reservoir		
Maximum allowable flood level	579.00 m (1899.61 ft)	183,000 dam^3 (149,000 ac-ft)
Full supply level	574.00 m (1883.20 ft)	96,600 dam^3 (78,300 ac-ft)
Normal level prior to spring runoff	573.00 m (1879.92 ft)	84,300 dam^3 (68,100 ac-ft)
Minimum supply level	564.00 m (1850.39 ft)	18,900 dam^3 (15,400 ac-ft)
Lake Darling Reservoir		
Maximum allowable flood level	1598.00 ft (487.07 m)	121,600 ac-ft (150,000 dam^3)
Full supply level	1597.00 ft (486.77 m)	110,000 ac-ft (136,000 dam^3)
Minimum supply level	1577.00 ft (480.67 m)	3,500 ac-ft (4,300 dam^3)

Table 3.2

Summary of Rafferty Elevation-Area-Capacity Data

Elevation in metres	Storage dam^3	Storage Ac-Ft	
547.5	305287	247500	Maximum required drawdown (1)
549.5	392371	318100	Normal drawdown (2)
550.5	439613	356400	FSL
554.0	632776	513000	Maximum storage level

Elevation		Surface Area		Adopted Storage	
metre	feet	ha	acres	dam^3	ac-ft
535.0	1755.25	0	0	0	0
537.0	1761.81	807	1992	4737	3840
538.0	1765.09	1464	3614	16159	13100
540.0	1771.65	2495	6159	56370	45700
545.0	1788.06	3574	8822	209075	169500
546.0	1791.34	3795	9367	245833	199300
547.0	1794.62	4022	9928	284811	230900
547.5	1796.26	4134	10205	305287	247500
549.0	1801.18	4480	11060	369675	299700
549.5	1802.82	4599	11353	392371	318100
550.0	1804.46	4719	11649	416547	337700
550.5	1806.10	4881	12048	439613	356400
551.0	1807.74	5045	12454	464406	376500
551.5	1809.38	5212	12866	490062	397300
552.0	1811.02	5407	13347	516582	418800
552.5	1812.66	5605	13836	543966	441000
553.0	1814.30	5807	14334	572459	464100
553.5	1815.94	6012	14841	602063	488100
554.0	1817.59	6222	15360	632776	513000
555.0	1820.87	6651	16418	697041	565100

1. Assuming starting elevation of 547.5 metres, flood control storage available would be 632,776 (513,000) - 305,287 (247,500) = 327,489 dam^3 (265,500 Ac-Ft) [FSL = 550.5].

2. Assuming starting elevation of 549.5 metres, flood control storage available would be 632,776 (513,000) - 392,371 (318,100) = 240,405 dam^3 (194,900 Ac-Ft) [FSL = 550.5].

3.2 Boundary Dam

The relevant data for this control point are shown on Tables 3.1 and 3.3.

Table 3.3

Summary of Boundary Elevation-Capacity Data

Elevation metre	Elevation feet	Storage dam^3	Storage Ac-Ft	
557.8	1830.0	44,725	36,259	Max required drawdown (1)
560.8	1840.0	61,480	49,845	FSL, Normal, & Max.

Elevation metre	Elevation feet	Surface Area ha	Surface Area acres	Storage dam^3	Storage ac-ft
554.7	1820.0	407	1,005	30,691	24,882
555.5	1822.5	425	1,049	33,970	27,540
556.3	1825.0	445	1,098	37,400	30,320
557.0	1827.5	486	1,200	41,000	33,240
557.8	1830.0	506	1,249	44,725	36,259
558.5	1832.5	546	1,348	48,625	39,420
559.3	1835.0	547	1,350	52,670	42,700
560.1	1837.5	607	1,498	56,910	46,140
560.8	1840.0	688	1,698	61,480	49,845

1. At maximum required drawdown level of 557.8 metres, (1830 feet), storage available would be 61,480 (49,845) - 44,725 (36259) = 16,755 dam^3 (13,586 ==> 13,600 Ac-Ft). This necessary storage may also be obtained by drawing Rafferty below required levels and diverting the 16,755 dam^3 (13,600 Ac-Ft) to Rafferty Reservoir.

3.3 Alameda Dam

The relevant data for this control point are shown on Tables 3.1 and 3.4. The storage-surface area-elevation curves are shown on Plate A-8.

Table 3.4
Summary of Alameda Elevation-Area-Capacity Data

Elevation in metres	Storage dam³	Storage Ac-Ft	
569.0	45812	37140	Maximum required drawdown (1)
573.0	84000	68100	Normal drawdown (2)
574.0	96619	78330	FSL
579.0	183369	148660	Maximum storage level

Elevation		Surface Area		Adopted Storage	
metre	feet	ha	acres	dam^3	ac-ft
547.5	1796.26	0	0	0	0
550.0	1804.46	1	2.5	7	6
555.0	1820.87	37	91	772	626
560.0	1837.27	208	513	6932	5620
565.0	1853.67	437	1079	22659	18370
566.0	1856.96	503	1242	27371	22190
567.5	1861.88	610	1506	35697	28940
569.0	1866.80	743	1833	45812	37140
570.0	1870.08	838	2069	53693	43530
571.0	1873.36	950	2344	62624	50770
572.5	1878.28	1129	2787	78166	63370
573.0	1879.92	1197	2954	84000	68100
574.0	1883.20	1338	3304	96619	78330
574.5	1884.84	1412	3486	103489	83900
575.0	1886.48	1488	3673	110730	89770
575.5	1888.12	1563	3857	118291	95900
576.0	1889.76	1639	4047	126346	102430
576.5	1891.40	1718	4240	134696	109200
577.0	1893.04	1798	4439	143454	116300
577.5	1894.69	1881	4643	152705	123800
578.0	1896.33	1989	4909	162450	131700
578.5	1897.97	2100	5183	172687	140000
579.0	1899.61	2217	5473	183369	148660
580.0	1902.89	2451	6050	206608	167500

1. Assuming starting elevation of 569.0 metres, flood control storage available would be 183,369 (148,660) - 45,812 (37,100) = 137,557 dam^3 (111,520 Ac-Ft) [FSL = 574.0].

2. Assuming starting elevation of 573.0 metres, flood control storage available would be 183,369 (148,660) - 84,000 (68,100) = 99,369 dam^3 (80,560 Ac-Ft) [FSL = 574.0].

3.4 Lake Darling

The relevant data for this control point are shown on Tables 3.2 and 3.5. The storage-surface area-elevation curves are shown on Plate A-9.

Table 3.5

Lake Darling Storage

Elevation		Storage		
feet	metres	ac-ft	dam^3	
1591	484.94	53,000	65,375	Maximum drawdown (1)
1596	486.46	99,000	122,115	Normal drawdown (2)
1597	486.77	110,100	135,800	Normal pool
1601	487.98	158,600	195,630	Existing maximum

Elevation		Surface Area		Adopted Storage	
feet	metres	acres	ha	ac-ft	dam^3
1591.0	484.94	7,431	3,010	53,000	65,375
1592.0	485.24	8,200	3,322	60,800	75,000
1593.0	485.55	8,910	3,610	69,400	85,600
1594.0	485.85	9,650	3,910	78,600	96,950
1595.0	486.16	10,220	4,140	88,600	109,290
1596.0	486.46	10,800	4,375	99,000	122,115
1597.0	486.77	11,270	4,566	110,100	135,800
1598.0	487.07	11,750	4,760	121,600	150,000
1599.0	487.38	12,150	4,922	133,600	164,790
1600.0	487.68	12,550	5,084	145,900	179,965
1601.0	487.98	12,900	5,226	158,600	195,630

Service spillway crest at 1598.0 feet.

1. Assuming a starting elevation of 1591 feet, flood control storage available would be 158,600 (195,630) - 53,000 (65,375) = 105,600 ac-ft (130,255 dam^3)

2. Assuming a starting elevation of 1596 feet, flood control storage available would be 158,600 (195,630) - 99,000 (122,115) = 59,600 ac-ft (73,515 dam^3)

3.5 Souris River near Sherwood

The International gaging station, number 05114000, latitude 48:59:24, longitude 101:57:28, on the Souris River, 0.8 mile downstream of the International boundary.

3.6 Souris River above Minot

The control point, Souris River above Minot, is a flow gaging station operated by the U.S. Geological Survey and maintained by the North Dakota State Water Commission. The station number is 05117500.

The station is located approximately 3.5 miles (5.8 km) west of Minot, North Dakota, and approximately 7 miles (11 km) downstream from the confluence of the Souris and Des Lacs Rivers. The coordinates of the station are latitude 48:14:45, longitude 101:22:15.

3.7 Diversion From Boundary to Rafferty Reservoir

Boundary Diversion may be used for flood control provided that storage is available in Rafferty in excess of the amount required to meet United States flood control requirements in that year, by the amount of volume to be diverted.

3.8 Other Considerations

This operating plan for the Canadian reservoirs and Lake Darling requires that flood protection be provided for urban and rural downstream areas. The operation of the Project for flood flows will consider the approximate bankfull channel capacities of urban and rural reaches. Release rates will be based on reducing flood damages as much as possible. An indication of the flows at which flooding occurs is provided in Table 3.6, for various reaches of the Souris River, Long Creek and Moose Mountain Creek. These flows should be considered as approximate only.

Table 3.6

Approximate Bankfull Channel Capacity

Description of Reach	Bankfull Capacity
<u>Long Creek</u>	
Boundary Dam to Souris River	Not Known
<u>Moose Mountain Creek</u>	
Alameda Dam to Souris River	Not Known
<u>Souris River</u>	
Rafferty Dam to Long Creek	14 m^3/s (500 cfs)*
Long Creek to Shand	85 m^3/s (3,000 cfs)
Shand to Moose Mountain Creek	60 m^3/s (2,000 cfs)
Souris River at Oxbow	90 m^3/s (3,200 cfs)
Souris River at International Boundary	90 m^3/s (3,200 cfs)
Sherwood to Upper Souris Refuge	60 m^3/s (2,000 cfs)
Upper Souris Refuge to Lake Darling Dam	Reservoir pool
Lake Darling Dam to Minot	2,500 cfs (70 m^3/s)
Souris River at Minot	5,000 cfs (215 m^3/s)
Minot to Logan	2,500 cfs (70 m^3/s)
Logan to Velva	1,400 cfs (40 m^3/s)
Velva to Verendrye	1,400 cfs (40 m^3/s)
Verendrye to Wintering River	1,500 cfs (42 m^3/s)
Wintering River to Towner	600 cfs (17 m^3/s)
Towner to Melita	200 cfs (6 m^3/s)

*With proposed channel improvements.

4.0 OPERATING PLAN

4.1 Objectives and Procedures

The objectives of this operating plan are: (1) 1 percent (100-year) flood protection at Minot, (2) to provide flood protection to urban and rural areas downstream from Rafferty, Boundary, Alameda, and Lake Darling Dams; (3) to ensure, to the extent possible, that the water supply benefits from these reservoirs are not compromised; and (4) to provide for sharing of the water of the Souris River basin.

In order to ensure that these objectives are met, it is necessary to distinguish between flood and nonflood operation. To meet the flood and nonflood operating plan objectives, the following procedure will be used to identify the proper mode of operation while complying with the terms of the International Apportionment.

Flood Operation

If a February 1 or subsequent spring runoff estimates shows a reasonable chance (50 percent) of a runoff volume at Sherwood being equal to or greater than a 10-percent (1 in 10 years) flood, then operations will proceed on the basis of the flood operating plan. Flood operation will cease when flood volumes have been discharged and streamflows are at or below 500 cfs at Minot.

Nonflood Operation

If a February 1 or subsequent spring runoff estimate shows a reasonable chance (50 percent) of a runoff event less than a 10-percent (1 in 10 years) flood, then operations will proceed on the basis of the nonflood operation plan.

4.2 International Apportionment

International apportionment is the amount of the natural flow that must be passed from Saskatchewan to North Dakota in any calendar year. In accordance with treaty obligations and orders of the International Joint Commission, North Dakota is entitled to 50 percent of the natural flow at Sherwood. Under certain conditions, a portion of the North Dakota share will be in the form of evaporation from Rafferty and Alameda reservoirs. During years when these conditions occur, the minimum amount of flow actually passed to North Dakota will be 40 percent of the natural flow at Sherwood. This lesser amount is in recognition of Saskatchewan's agreement to operate both Rafferty Dam and Alameda Dam for flood control and for evaporation as a result of the Project. Therefore, this is deemed to be in compliance with all applicable obligations. The volume of natural flow will be determined by the International Souris River Board of Control.

The following rules determine the percentage of the natural flow at Sherwood which is to be passed to North Dakota.

a. If the level of Lake Darling is below an elevation of 1592.0 feet (485.24 metres) on October 1 in any calendar year, Saskatchewan will pass 50 percent of the natural flow at Sherwood in that year and in succeeding years, until the level of Lake Darling is above an elevation of 1593.0 feet (485.55 metres) on October 1.

b. If the natural flow at Sherwood is equal to or less than 15,000 acre-feet (18,500 cubic decametres) prior to Oct. 1 of that year, then Saskatchewan will pass 50 percent of that natural flow to North Dakota in that calendar year.

c. For other years, Saskatchewan will pass at least 40 percent of the natural flow at Sherwood to North Dakota.

d. If releases are delayed, they may be called for at any time before October 1. If they are not called for before October 1, the water may be retained for use in Saskatchewan.

Lake Darling and the Canadian reservoirs will be operated (insofar as is compatible with the Project's purposes and consistent with past practices) to ensure that the pool elevations, which determine conditions for sharing evaporation losses, are not artificially altered. The triggering elevation of 1592.0 feet (485.24 metres) for Lake Darling is based on existing water uses in North Dakota, including refuges operated by the U.S. Fish and Wildlife Service. Each year, operating plans for the refuges on the Souris River will be presented to the International Souris River Board of Control. Barring unforeseen circumstances, operations will follow said plans during each given year. Lake Darling will not be drawn down for the sole purpose of reaching the pool elevation of 1592.0 feet (485.24 metres) on October 1.

Late season releases will not be made by Saskatchewan Water Corporation from the Canadian reservoirs for the sole purpose of raising the pool elevation of Lake Darling above 1593.0 feet (485.55 metres) on October 1.

Regardless of the above rules, North Dakota (and the U.S. Fish and Wildlife Service) will assess its storage capability and need prior to release from the Canadian dams. If there will be no benefit in North Dakota from the release, the water may be retained for use in Saskatchewan. To the extent possible and in consideration of potential channel losses and operating efficiencies, releases from the Canadian dams under the above rules will be scheduled to coincide with periods of beneficial use in North Dakota. Normally, the period of beneficial use in North Dakota coincides with the timing of the natural hydrograph, and that timing should be a guide to releases of the United States portion of the natural flow. All releases will be within the specified target flows at control points, and the timing of said releases will be coordinated with the U.S. Fish and Wildlife Service.

4.3 Flood Operation

General

This section sets forth the draft operating plan for Rafferty, Alameda, Boundary, and Lake Darling Reservoirs for flood control. In general, the purpose is as follows: the three reservoirs in Canada are to be operated in such a manner so that along with Lake Darling it will be possible to obtain 1-percent (100-year) level of protection at Minot. The 1-percent level of protection at Minot allows a maximum discharge of 5,000 cfs. After the spring estimate of streamflow is received, if a 1-percent or greater flood volume is anticipated, it will be necessary to draw Lake Darling down to an elevation of 1591.0 feet, to draw Rafferty down to an elevation of 547.5 metres, to draw Alameda down to an elevation of 569.0 metres, and to draw Boundary down to an elevation of 557.8 metres given that the estimated 90- day volume as set forth in Plates A-1 to A-3 and the estimated 30-day volume in Plate A-4 will require the maximum required drawdown levels. As discussed in Section 3.2, additional drawdown in Rafferty may be used in lieu of drawdown of Boundary. The manner in which this is to be accomplished and

the reasons for doing so are presented in the following sections. In those cases where the flood event is greater than a 1 percent (100-year) event, the Project will be operated as set forth in the Reservoir Regulation Manuals to attempt to reduce downstream damages without endangering the structures themselves. This may require flows greater than 5,000 cfs at Minot for the period before 1 June, and may also require flows greater than 500 cfs (which could also exceed 5,000 cfs) after 1 June.

The Canadian Reservoirs will be operated for Sherwood giving due consideration to the level at Lake Darling and the flow at Minot. It is not possible to obtain 1-percent (100-year) flood protection at Minot unless Rafferty, Alameda, Boundary, and Lake Darling are operated as a complete system.

This operating plan will be used when the estimated 30-day unregulated volume at Sherwood equals or exceeds a 10-percent (10-year) event, which is equal to 175,200 Ac-Ft (216,110 dam^3); and/or when the local 30-day volume at Sherwood is expected to equal or exceed 30,000 acre-feet, (37,000 dam^3). From the period of record at Sherwood, 1930 to 1986, 56 years, the operating plan would have been used approximately 6 times, or about 10 to 11 percent of the time.

The flood operating plan is divided into four separate phases in accordance with the annual hydrograph. These phases relate to:

a. Operations to lower reservoirs prior to spring runoff.
b. Operations during spring runoff.
c. Operations after runoff to restore reservoirs to full supply level.
d. Operations during the summer, fall, and winter.

4.3.1 Drawdown Prior to Spring Runoff

The drawdown of Rafferty, Boundary, and Alameda Reservoirs and Lake Darling in response to a given predicted flood event is an integral part of the operating plan. The extent of drawdown will depend on the estimated spring runoff volume for each as shown on the curves in Plates A-1 to A-4.

Any releases from Lake Darling must take into consideration inflows resulting from releases from the Canadian reservoirs and any local inflow between the Canadian reservoirs and Lake Darling.

Regardless of the estimated volumes of runoff, the reservoirs will be operated to ensure that each is at or below the following pool levels by February 1.

a. Rafferty Reservoir - 549.50 m. (1802.82 ft.)
b. Alameda Reservoir - 573.00 m. (1879.92 ft.)
c. Lake Darling - 1596.00 ft. (486.46 m.).

The reservoirs will be drawn down, as appropriate, over the summer, fall, and winter months, and release rates will take into consideration channel and ice conditions. Release rates will be set to ensure that the maximum controlled flow at Sherwood will not exceed the following rates, provided Lake Darling is at or below full supply level:

a.	June 1 to August 31	- 11 m^3/s (400 cfs)
b.	September 1 to January 31	- 14 m^3/s (500 cfs)
c.	February 1 to March 15	- 60 m^3/s (2120 cfs)
d.	March 16 to May 31	- 90 m^3/s (3200 cfs; up to 50-yr) 113 m^3/s (4000 cfs; over 50-yr)

Estimates of spring runoff will be made initially on February 1 and thereafter on the 15th and last day of each month until runoff occurs. The target drawdown levels will be as shown on Plates A-1 through A-4. For the Canadian reservoirs, these levels are based on the 90- percent spring runoff volume for each reservoir. Using this parameter will ensure that operating the Canadian reservoirs for flood control will not compromise the water supply potential. For Lake Darling, the target drawdown level is based on the estimated Sherwood uncontrolled runoff volume and a sliding scale relating the runoff volume to a Lake Darling pool level as is shown on Plate A-4. As the estimated spring runoff volume is updated thru the spring, the Lake Darling target level will also change.

Should the pool level of any reservoir on February 1 be higher than its target drawdown level, releases will be made as described below. Should the pool level for a reservoir on February 1 be equal to or lower than the target drawdown level, no releases need be made from that reservoir.

Channel Ice Effects

To avoid ice problems, the Reservoir Regulation Manuals will include features that will directly address the ice problems that may occur.

Rafferty and Alameda Reservoirs

The drawdown of Rafferty and Alameda Reservoirs will be the responsibility of the Saskatchewan Water Corporation. Releases from each reservoir will be made to achieve its target drawdown level. While the reservoirs are being drawn down, the total flow at Sherwood should not exceed the peak target flow from Plate A-5.

The release rate will take into consideration ice and channel conditions between the Canadian reservoirs and Lake Darling. Such releases will be reviewed and adjusted as necessary on a regular basis, at a minimum after each estimate of the spring runoff volume.

Releases will be established to achieve the target drawdown levels prior to the occurrence of spring runoff to the reservoirs.

Boundary Reservoir and Flood Diversion Channel

Both Boundary Reservoir and the flood diversion channel (to divert flows from Boundary Reservoir to Rafferty Reservoir) will be operated within the limits of the drawdown curves. Boundary will be drawn down to the elevation shown on Plate A-2 provided that the associated drawdown volume shown on Plate A-2 is equal to the estimated 90-percent 90-day runoff volume. To operate the diversion channel there must be excess capacity available in Rafferty Reservoir to store the diverted amount. This excess capacity must be in addition to the capacity that would be made available as per Plate A-1. The operation of each will attempt to maximize flood reduction within the constraints of water supply requirements. The operation of each will be such to ensure that the resulting peak flow at Sherwood during runoff is not greater than the peak that would have occurred without the operation of Boundary Reservoir and flood diversion channel; and that flood control be provided as setforth above.

Preflood Lake Darling Spring Drawdown

Drawdown of the Lake Darling pool prior to a given flood event is an integral part of the overall operating plan. Lake Darling pool drawdown is the first step in the operating plan and is important because the extent of pool drawdown has a direct relationship to the amount of storage available for flood control. Drawdown is dependent upon the runoff volume (uncontrolled) at Sherwood, the rate of drawdown, and the time available for drawdown between March 1 and spring breakup. In addition, it must include the release of water from the Canadian dams if needed, or it could be reduced based on pool levels in Canada lower than what is needed for flood control based on the estimated 30-day volume. The rate of drawdown shall be reviewed and adjusted on a regular schedule as the winter progresses, to ensure that the pool will be at or below the target elevation by April 1.

4.3.2. Spring Runoff

If the estimated uncontrolled volume is sufficient to raise Lake Darling to its full supply level of 1597.0 feet, then the Canadian dams will store water until they have reached their respective full supply levels of 550.5 metres for Rafferty Reservoir and 574.0 metres for Alameda Reservoir. Once a reservoir has reached its full supply level, excess water will be released at a controlled rate in accordance with the terms of the operating plan.

If reservoir target drawdown levels for Rafferty and Alameda were not reached prior to the spring runoff, then the volume in the reservoir above the target drawdown level on February 1 will be released within the specified target flows at control points, and they will be coordinated with the U.S. Fish and Wildlife Service.

At the discretion of the Saskatchewan Water Corporation, any of the Canadian reservoirs may be drawn down below its target drawdown level. Releases resulting from said drawdown will remain within the specified target flows at control points, and they will be coordinated with the U.S. Fish and Wildlife Service.

At the discretion of the U.S. Fish and Wildlife Service, Lake Darling may be drawn down below its target drawdown level for resource management purposes. Releases resulting from said drawdown will remain within the specified target flows at control points, and they will be coordinated with the Saskatchewan Water Corporation and the U.S. Army Corps of Engineers.

Sherwood Target Flow

The Sherwood target flow is a function of the Lake Darling pool level which is itself a function of the target flow at Minot. To enable the operation of the total system for those objectives set forth in Section 4.1, it is necessary to vary the target flows at Sherwood as given on Plate A-5.

The maximum target flow at Sherwood will be as provided in Plate A-5, except, that under certain conditions, the target flow may be temporarily lowered. Once Lake Darling pool levels are lowered to a level which allows the Minot target flow to be maintained, the Sherwood target flow can be increased to the starting value as was determined from Plate A-5. If releases from the Canadian Reservoirs are not increased then the Lake Darling operator must be notified immediately and releases from Lake Darling reduced accordingly. The maximum target flow will continue while water remains above FSL in either Rafferty or Alameda and Lake Darling is below 1597 feet. By having a varying target flow at Sherwood the summer release period would decrease as well as the problems which occur with long summer releases.

Lake Darling Level

The release of the maximum target flow at Sherwood will allow Lake Darling to release water at the Minot target level which may be above the Sherwood maximum target level resulting in the lowering of the Lake Darling pool below 1597 feet. The need to draw Lake Darling below 1597 feet will only occur when there is sufficient water in Rafferty and/or Alameda above their FSL's to

fill Lake Darling back to 1597 feet and will enable releases of excess water during the period before 15 May and at reduced levels before 1 June. The drawing of Lake Darling pool below 1597 feet will allow the summer release period to be shortened and in some cases it will not be needed.

4.3.3 Drawdown after Spring Runoff

If any of the reservoirs are above full supply level after the spring runoff has occurred, the reservoir or reservoirs will be brought down to full supply level using the methods outlined in Section 4.3.2. It should be noted that at no time will releases from the Canadian reservoirs cause the flows at Sherwood to exceed the target flow from Plate A-5 unless the flow cannot be controlled by the reservoirs.

Post-Peak Flood Storage Release

After the peak stage has been reached in Lake Darling, target releases are maintained until the pool has returned to full supply level, with the following exceptions:

a. After June 1, 500 cfs or less is maintained.
b. After May 15, but before June 1, the target flow at Minot is maintained at a level not to exceed 2500 cfs until pool levels reach FSL, unless the 5000 cfs target must be extended to enable the desired reservoir pool levels to be reached by Feburary 1 of the following year.

4.3.4 Significant Spring and Summer Rainfall

If significant rainfall occurs during the spring or summer flood recession, the Reservoir Regulation Manual will provide for discharging the rainfall runoff based on following the unregulated flow recession. All rainfall inflow to Lake Darling above FSL is discharged until the unregulated flow recession at Minot reaches 500 cfs. All rainfall runoff above Lake Darling which would cause flows in excess of 500 cfs at Minot would be stored, but not to exceed pool elevation 1598 feet. (Des Lacs flow could at times cause flows higher than 500 cfs at Minot.)

4.3.5 <u>Flood System Operation Steps</u>

The following operating steps would be used when the February 1 flow estimate exceeds the limits as set forth in Section 4.3.

<u>OPERATING PLAN STEPS</u>

These steps use English Units only to avoid confusion.

I. PRE-FLOOD (1 February to start of runoff)

   A. Determine Sherwood 30-day volume

   B. Determine Rafferty 30-day volume

   C. Determine Alameda 30-day volume

   D. Determine local Sherwood 30-day volume:

      1. Subtract Rafferty from Sherwood 30-day volume [I.A - I.B = I.D.1]

      2. Subtract Alameda from result of above [I.D.1 - I.C = I.D.3]

      3. This result is the Sherwood local 30-day volume

   E. Determine 30-day volume not controlled by Rafferty and Alameda

      1. Determine Rafferty starting storage value in Ac-Ft

         Based on the estimated runoff volume and Plate A-1, determine what pool level Rafferty should be at or below.

         a. If the actual pool level is below that level required, use the actual level in the following steps.

         b. If the actual pool level is above the level required, use the level shown on Plate A-1 in the following steps.

      2. Subtract starting storage from 513,000 Ac-Ft [513,000 - I.E.1=I.E.2]

      3. Determine if 30-day volume is controlled:

         a. if result from E.2 above is larger than 30-day volume there is no excess [I.E.2 > I.B],

         b. if not, subtract E.2 amount from 30-day value, this is the Rafferty excess [I.B - I.E.2 = I.E.3b.]

4. Determine Alameda starting storage value in Ac-Ft

   Based on the estimated runoff volume and Plate A-3, determine what pool level Alameda should be at or below.

   a. If the actual pool level is below that level required, use the actual level in the following steps.

   b. If the actual pool level is above the level required, use the level shown on Plate A-3 in the following steps.

5. Subtract starting storage from 148,660 Ac-Ft [148,660 - I.E.4=I.E.5]

6. Determine if 30-day volume is controlled:

   a. if result from E.5 above is larger than 30-day volume there is no excess [I.E.5 > I.C],

   b. if not, subtract E.5 amount from 30-day value, this is the Alameda excess [I.C - I.E.5 = I.E.6b.]

7. If it is determined that the estimated 30-day volumes from Rafferty and Alameda will not exceed their FSL's and therefore minimum releases are expected, the Lake Darling operater MUST be informed, so that Lake Darling can be at full supply level after flood

   [If (I.B - (356,400 - I.E.1)) < 0 and (I.C - (78,330 - I.E.4)) < 0, then call]

F. Determine the uncontrolled 30-day volume at Sherwood by adding the Rafferty and Alameda excesses if any to the Sherwood local 30-day volume found above [I.D.3+I.E.3.b + I.E.6.b = I.F.]

G. Using result from "F" above determine Lake Darling starting pool level from Plate A-4 [I.F + Plate A-4 ==> I.G]

H. Determine starting Sherwood target flow by using Plate A-5 and the total Sherwood 30-day volume from "A" above [I.A + Plate A-5 ==> I.I]

I. Determine Minot target flow by using Plate A-6 and the total Sherwood 30-day volume from "A" above [I.A + Plate A-6 ==> I.H]

J. Determine Boundary 30-day volume

K. Determine if Boundary storage must be used from Plate A-2

L. Determine if Diversion Channel will be used

M. Adjust estimate of 30-day voulume at Sherwood based on use of Boundary and/or Diversion Channel

II. DURING FLOOD (16 March to 31 May)

A. Using data as is available from within basin estimate the peak discharge to be expected at Sherwood:

1. if discharge is less than target flow at Sherwood, releases can be made from Rafferty and Alameda which increase the peak to, but not greater than, target

2. if discharge is greater than target flow at Sherwood, releases are not to be made from Rafferty and Alameda which will add to the peak flow at Sherwood

B. Sherwood Target - After peak at Sherwood

After the peak flow has occurred at Sherwood, estimate the average daily flows expected at Sherwood from the uncontrolled areas. Using this flow, the current Lake Darling pool elevation, and the local flows at Minot, estimate future Lake Darling pool elevations. Using this data, to include the Sherwood target flows, make releases to drawdown Rafferty and Alameda within the target flows in Plate A-5. Plate A-9 contains storage data for Lake Darling to aid in the estimates.

Repeat this operation as needed to reduce pool levels to FSL.

Note: The same starting Sherwood target flow is used for the entire flood event, UNLESS, the estimated 30-day volume at Sherwood is adjusted based on updated data.

C. To aid in the operation of ALL reservoirs ALL operators must communicate on a regular basis.

D. Based on reservoir levels, determine if the Minot target date of 15 May must be extended so that the 500 cfs maximum at Minot after 1 June will not be exceeded.

III. POST FLOOD (1 June to 31 January)

A. Following the operating guidelines, release allowable flows to bring the reservoirs to their FSL's

B. Review actions taken during flood and note problems which occurred

C. If flood was a large event, prepare a Post Flood Report

4.4 Nonflood Operation

Primary emphasis is given to operations during years of flood runoff; i.e., when the spring runoff volume exceeds a 10-percent flood. Nonflood operations are guided primarily by the International Souris River Board of Control (see Section 4.1, International Apportionment). This operating plan reflects the agreement between the parties regarding flows in nonflood years, and some guidance on the implementation of that agreement. It is recognized, however, that the actual implementation of the agreement will be dependent upon the close coordination of the parties during the hydrologic year.

4.4.1. Nonflood Project Operation Steps

1. The flow passed to North Dakota shall be either 40 percent or 50 percent of the natural flow at Sherwood according to the conditions listed in Section 4.1 as determined by the International Souris River Board of Control.

2. At the May meeting of the International Souris River Board of Control, an apportionment balance will be estimated.

3. If additional releases are needed to meet the apportionment balance, the interested parties in North Dakota will assess their needs. If the releases would not be of benefit at that time, they may be delayed.

4. If releases are delayed, they may be called for at any time before October 1. If they are not called for before October 1, the water may be retained for use in Saskatchewan.

5. If delayed releases are called for, the released volume which has been delayed will be measured at the point of discharge from the Canadian reservoirs and not at the Sherwood gage.

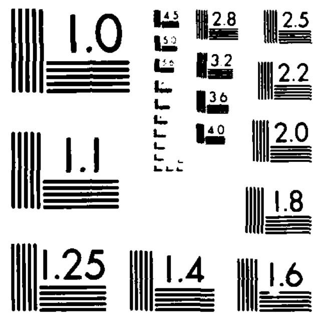
6. On October 1, a final apportionment balance will be determined. Any portion of the North Dakota apportionment remaining in Saskatchewan on October 1 shall be [illegible] arithmetically to the storage in Lake Darling on Oct [illegible] to determine the October 1 level of Lake Darling for [illegible] of Section 4.2.a.

4.5 Operating Provisions During Construction and [illegible]

All parties agree to use their best efforts [illegible] protection during construction of the Project

AD-A189 263 SOURIS RIVER BASIN PROJECT SASKATCHEWAN CANADA - NORTH DAKOTA USA GENERAL..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT NOV 87 2/5

UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

5.0 REPORTS

Reports will be prepared each year by both the Saskatchewan Water Corporation and the United States Fish and Wildlife Service(1) describing the operation of the Project from September 1 to the end of the spring runoff. The report will be issued to the International Souris River Board of Control by May 15 and as a minimum will include a description of the operation of the reservoirs including any problems encountered, a summary of water levels, inflows and releases from each reservoir, and an estimate of reservoir levels, inflows and releases for the remainder of the calendar year.

6.0 LIAISON

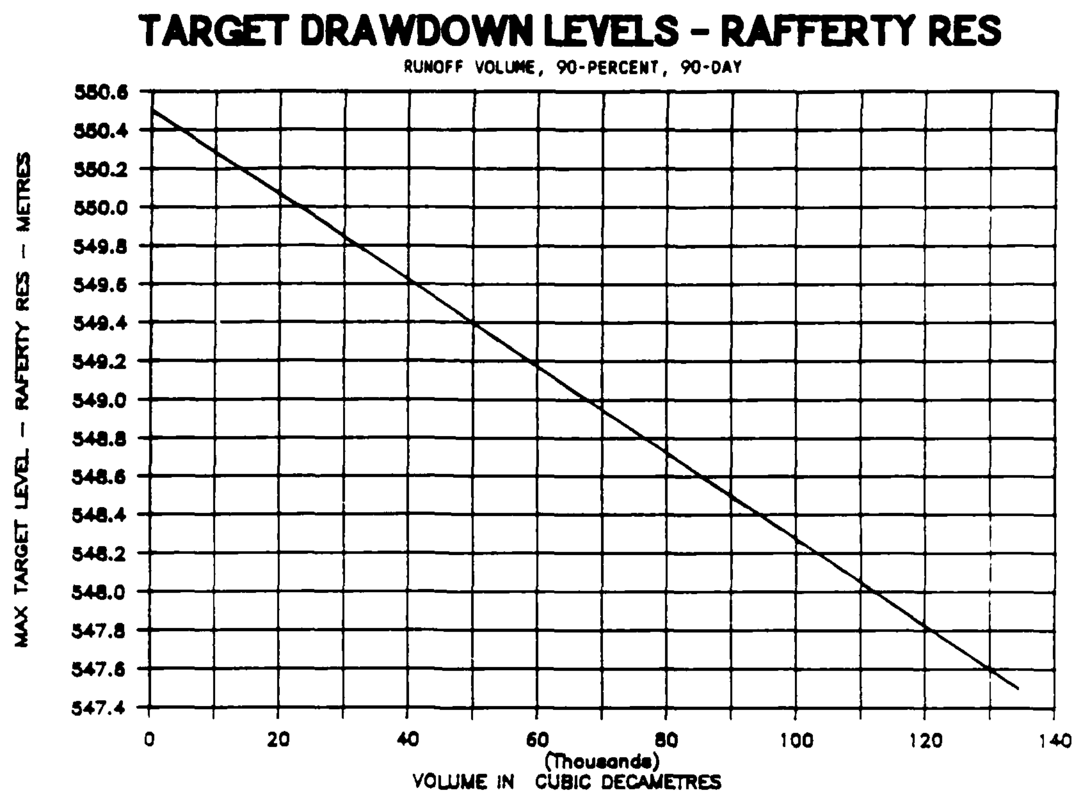
Each of the parties shall appoint a liaison person with whom the other parties may consult from time to time as to the operation of the works.

Representatives from the U.S. Army Corps of Engineers, Saskatchewan Water Corporation, U.S. Fish and Wildlife Service, and the North Dakota State Water Commission will be responsible for monitoring and updating the operating plan. It is expected that the reservoir operations will need to be closely monitored for the first several years after the project goes into operation.

7.0 DATA AND COMMUNICATION

The parties shall exchange all desirable data collected with respect to the management of water in the Souris River Basin and keep open the lines of communication between one another with the full intention of having all parties adequately informed of all activities related to this agreement.

(1) In any year in which flood operations occur, the U. S. Army Corps of Engineers will prepare a post-flood report. This report will then become a part of the Fish and Wildlife Service report.


TARGET DRAWDOWN LEVELS - RAFFERTY RES
RUNOFF VOLUME, 90-PERCENT, 90-DAY
MAX TARGET LEVEL - RAFFERTY RES - METRES
550.6
550.4
550.2
550.0
549.8
549.6
549.4
549.2
549.0
548.8
548.6
548.4
548.2
548.0
547.8
547.6
547.4
0
20
40
60
80
100
120
140
(Thousands)
VOLUME IN CUBIC DECAMETRES

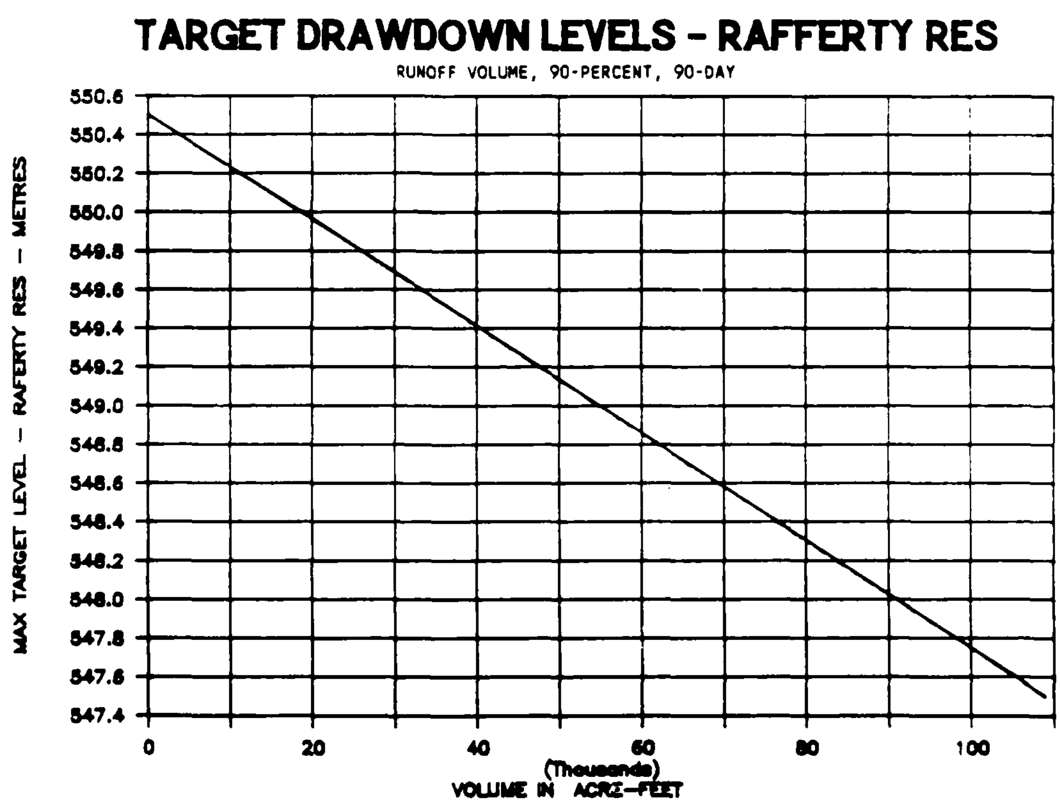
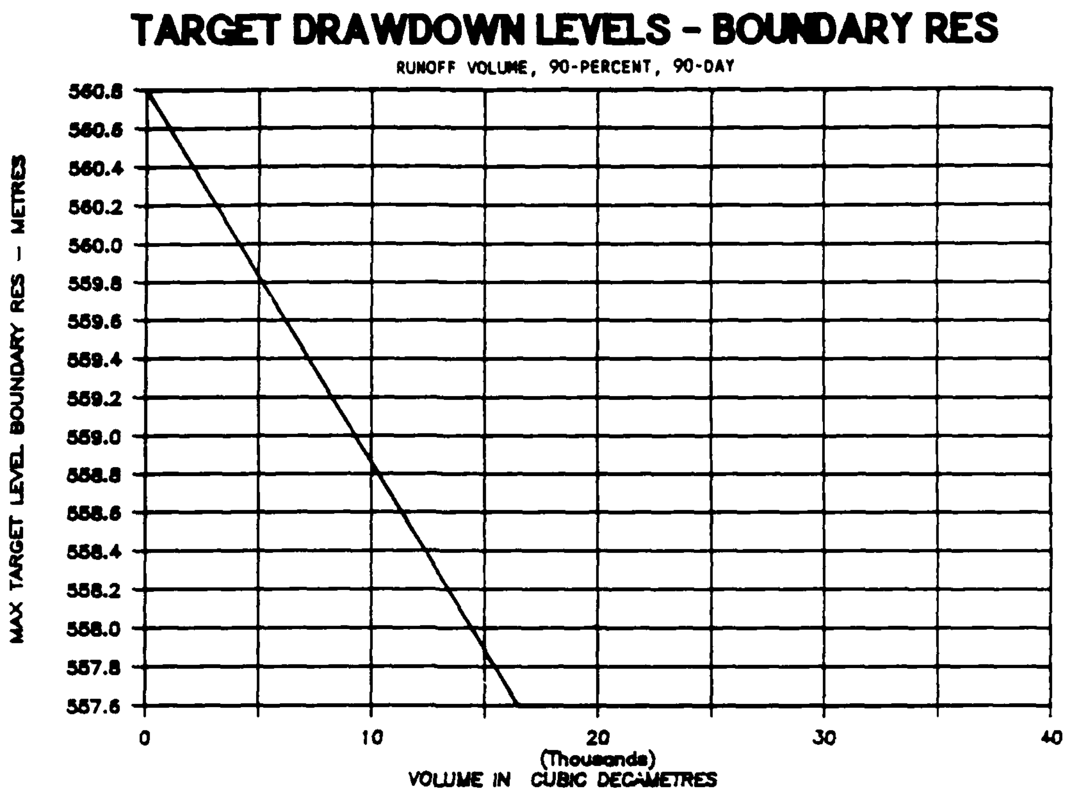
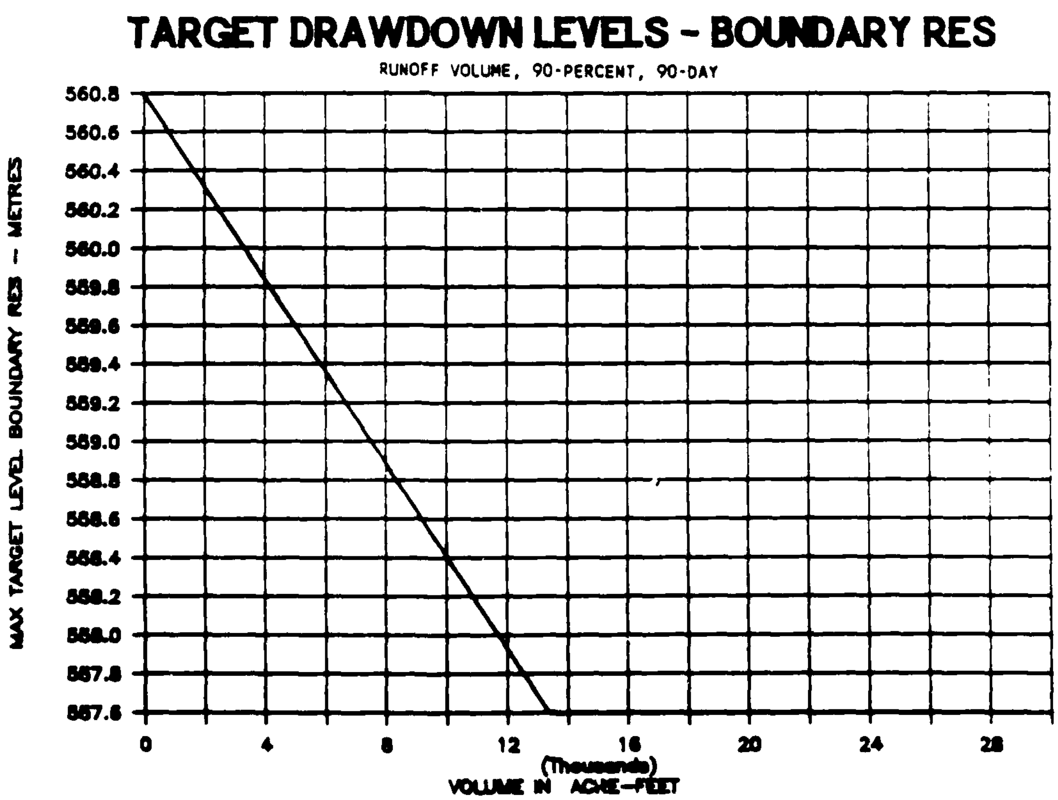
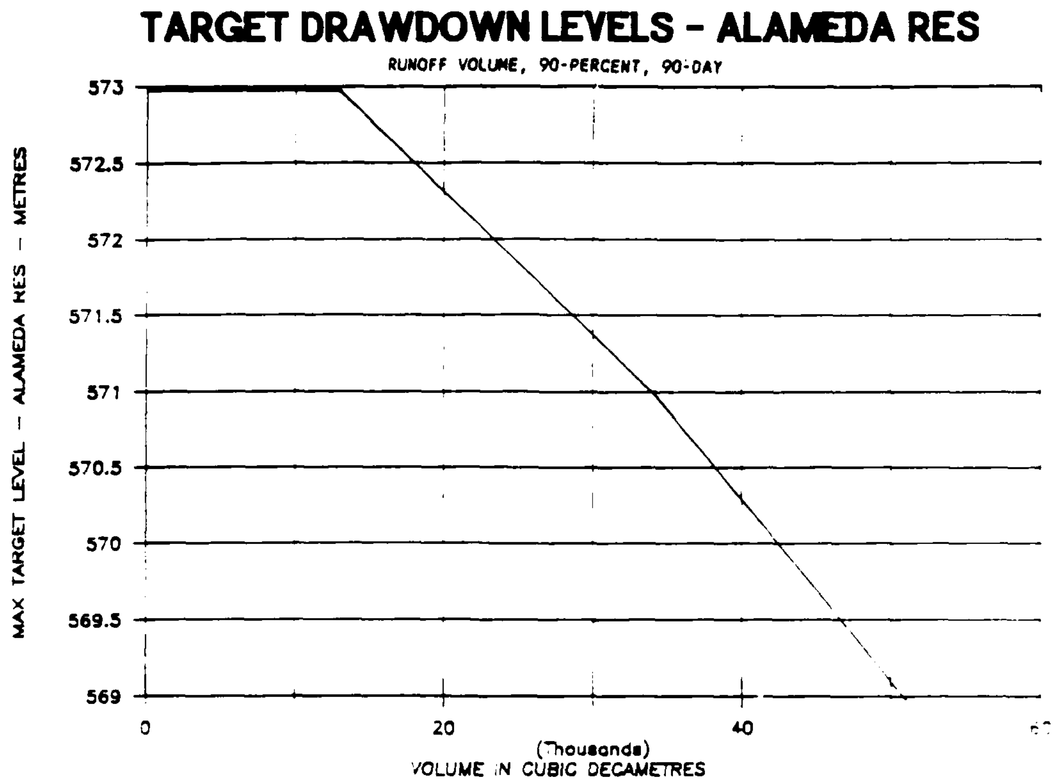

TARGET DRAWDOWN LEVELS - RAFFERTY RES
RUNOFF VOLUME, 90-PERCENT, 90-DAY
MAX TARGET LEVEL - RAFFERTY RES - METRES
550.6
550.4
550.2
550.0
549.8
549.6
549.4
549.2
549.0
548.8
548.6
548.4
548.2
548.0
547.8
547.6
547.4
0
20
40
60
80
100
(Thousands)
VOLUME IN ACRE-FEET

PLATE A-1


TARGET DRAWDOWN LEVELS - BOUNDARY RES
RUNOFF VOLUME, 90-PERCENT, 90-DAY
MAX TARGET LEVEL BOUNDARY RES - METRES
560.8
560.6
560.4
560.2
560.0
559.8
559.6
559.4
559.2
559.0
558.8
558.6
558.4
558.2
558.0
557.8
557.6
0
10
20
30
40
(Thousands)
VOLUME IN CUBIC DECAMETRES


TARGET DRAWDOWN LEVELS - BOUNDARY RES
RUNOFF VOLUME, 90-PERCENT, 90-DAY
MAX TARGET LEVEL BOUNDARY RES - METRES
560.8
560.6
560.4
560.2
560.0
559.8
559.6
559.4
559.2
559.0
558.8
558.6
558.4
558.2
558.0
557.8
557.6
0
4
8
12
16
20
24
28
(Thousands)
VOLUME IN ACRE-FEET


TARGET DRAWDOWN LEVELS - ALAMEDA RES
RUNOFF VOLUME, 90-PERCENT, 90-DAY
573
572.5
572
571.5
571
570.5
570
569.5
569
MAX TARGET LEVEL - ALAMEDA RES - METRES
0
20
40
(Thousands)
VOLUME IN CUBIC DECAMETRES

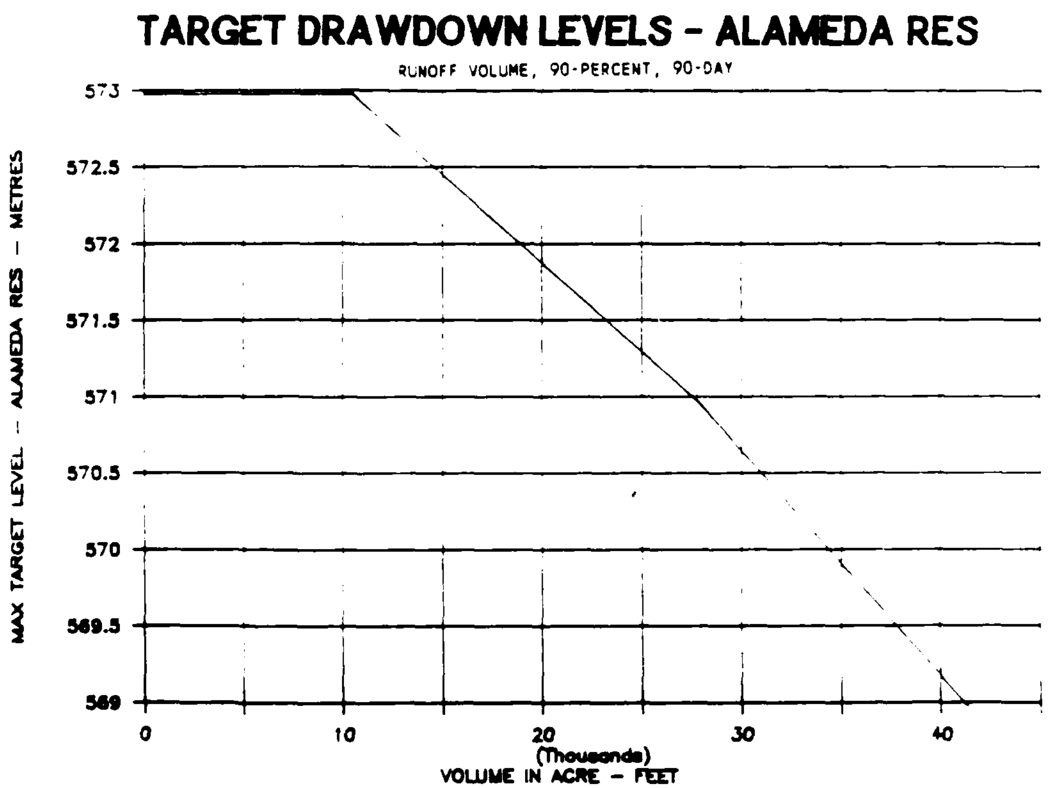
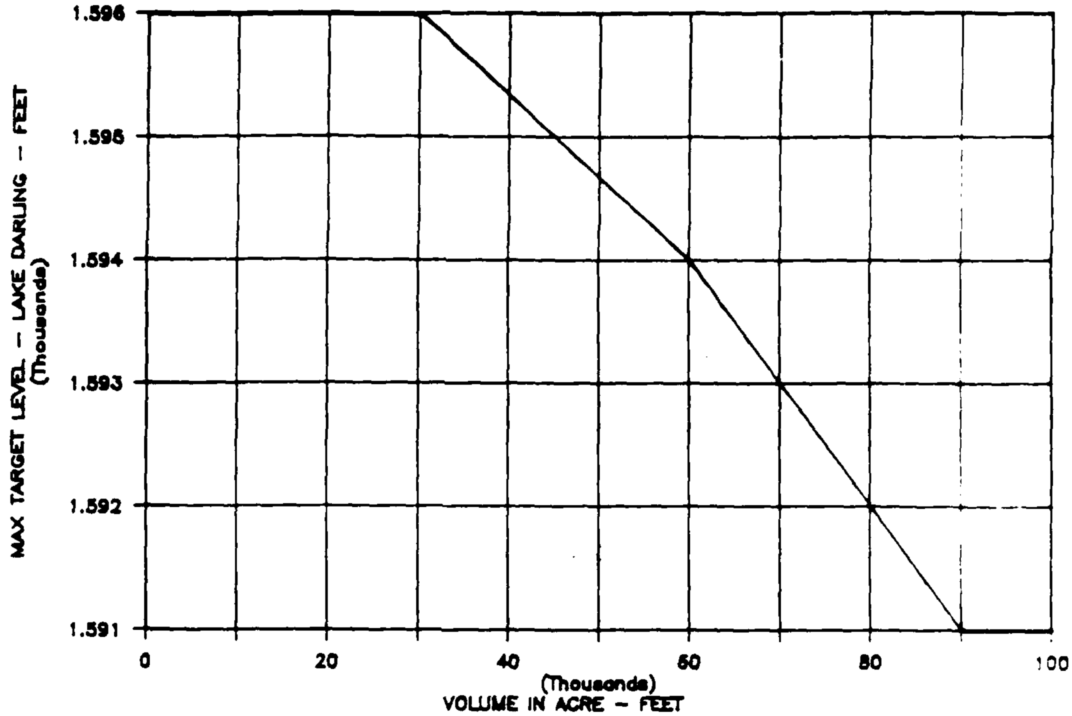

TARGET DRAWDOWN LEVELS - ALAMEDA RES
RUNOFF VOLUME, 90-PERCENT, 90-DAY
573
572.5
572
571.5
571
570.5
570
569.5
569
MAX TARGET LEVEL - ALAMEDA RES - METRES
0
10
20
30
40
(Thousands)
VOLUME IN ACRE - FEET

PLATE A-3

TARGET DRAWDOWN LEVELS - LAKE DARLING

UNCONTROLLED RUNOFF VOLUME, 30-DAY



TARGET DRAWDOWN LEVELS - LAKE DARLING

UNCONTROLLED RUNOFF VOLUME, 30-DAY

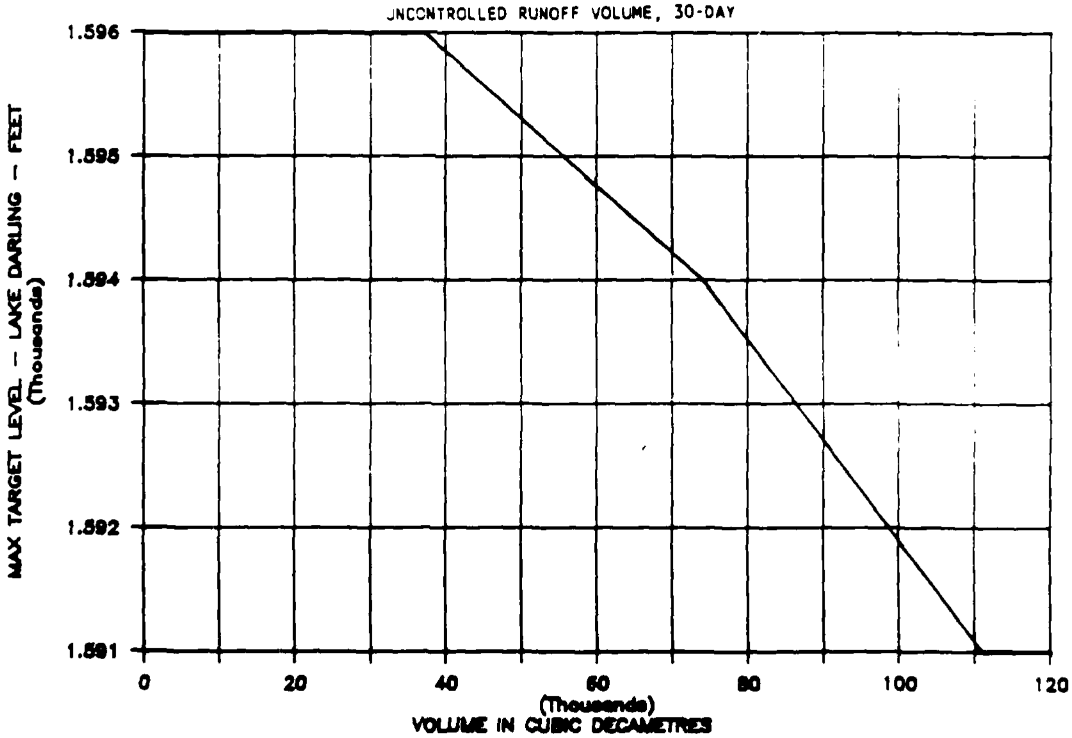
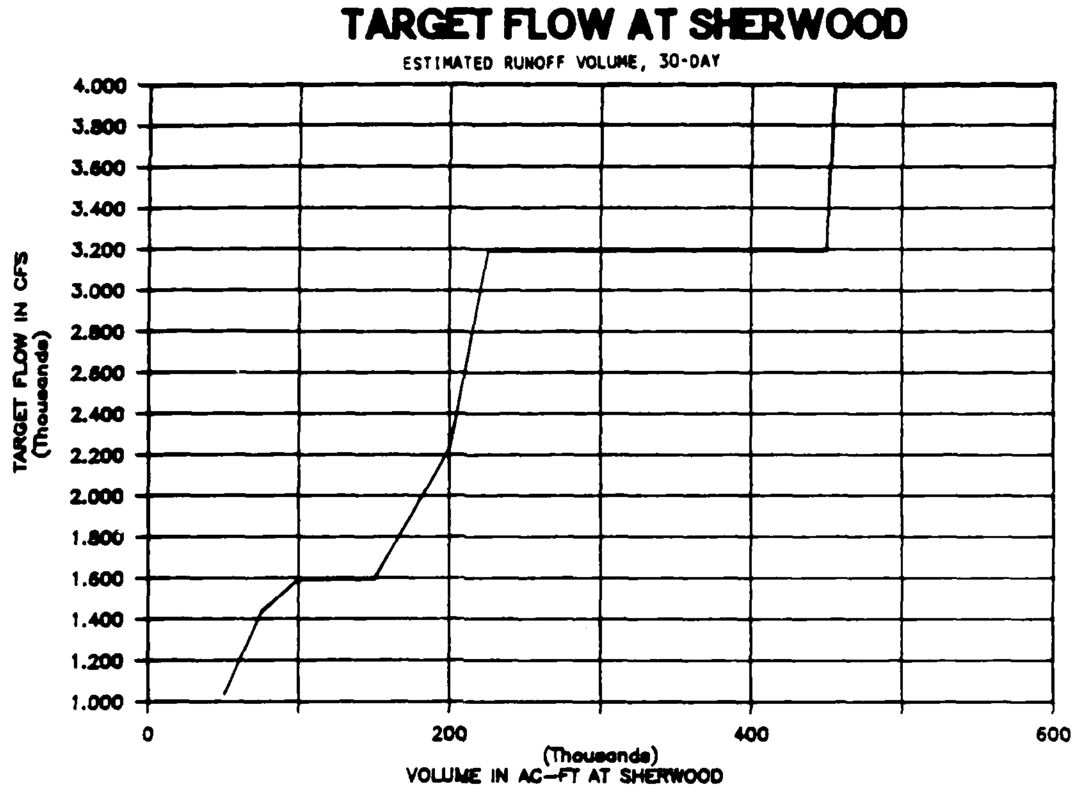


PLATE A-4


TARGET FLOW AT SHERWOOD
ESTIMATED RUNOFF VOLUME, 30-DAY
TARGET FLOW IN CFS (Thousands)
4.000
3.800
3.600
3.400
3.200
3.000
2.800
2.600
2.400
2.200
2.000
1.800
1.600
1.400
1.200
1.000
0
200
400
600
(Thousands)
VOLUME IN AC-FT AT SHERWOOD

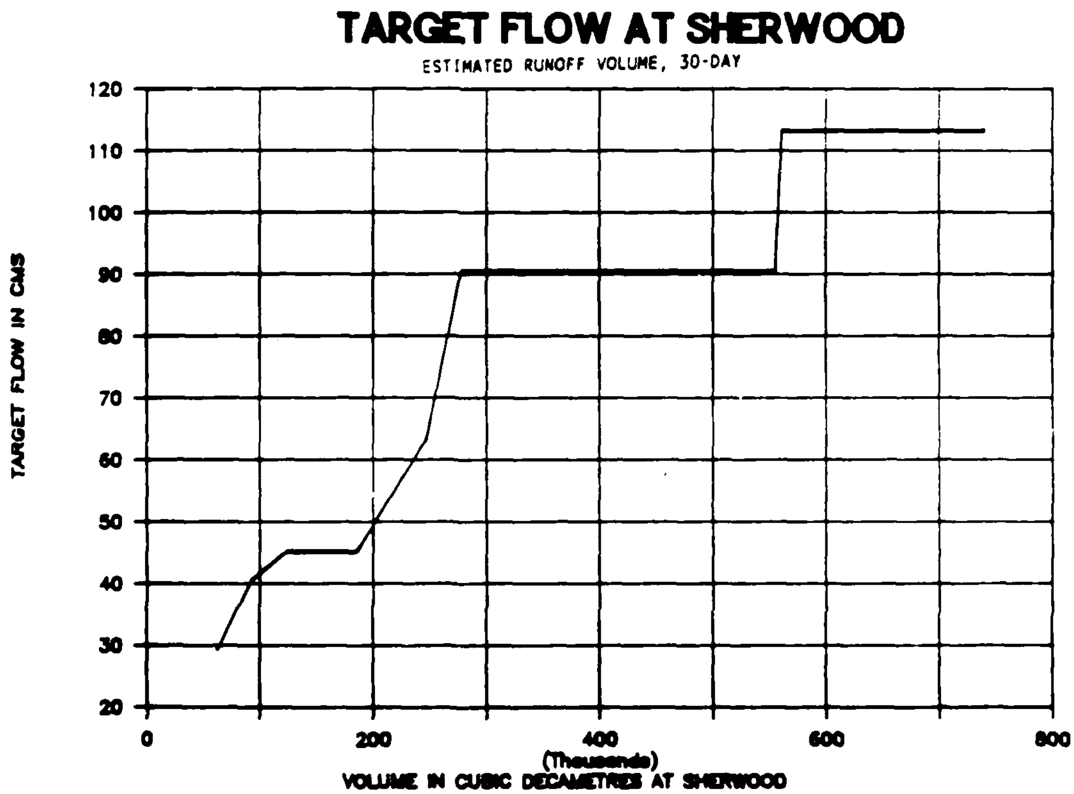
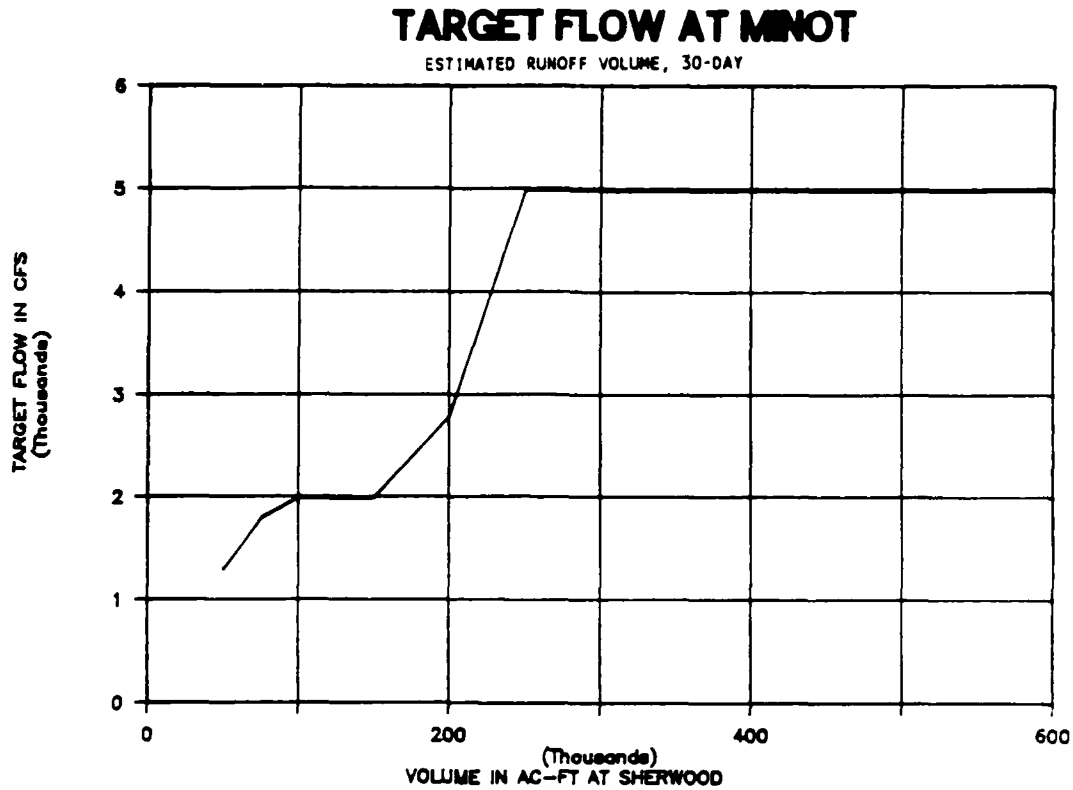
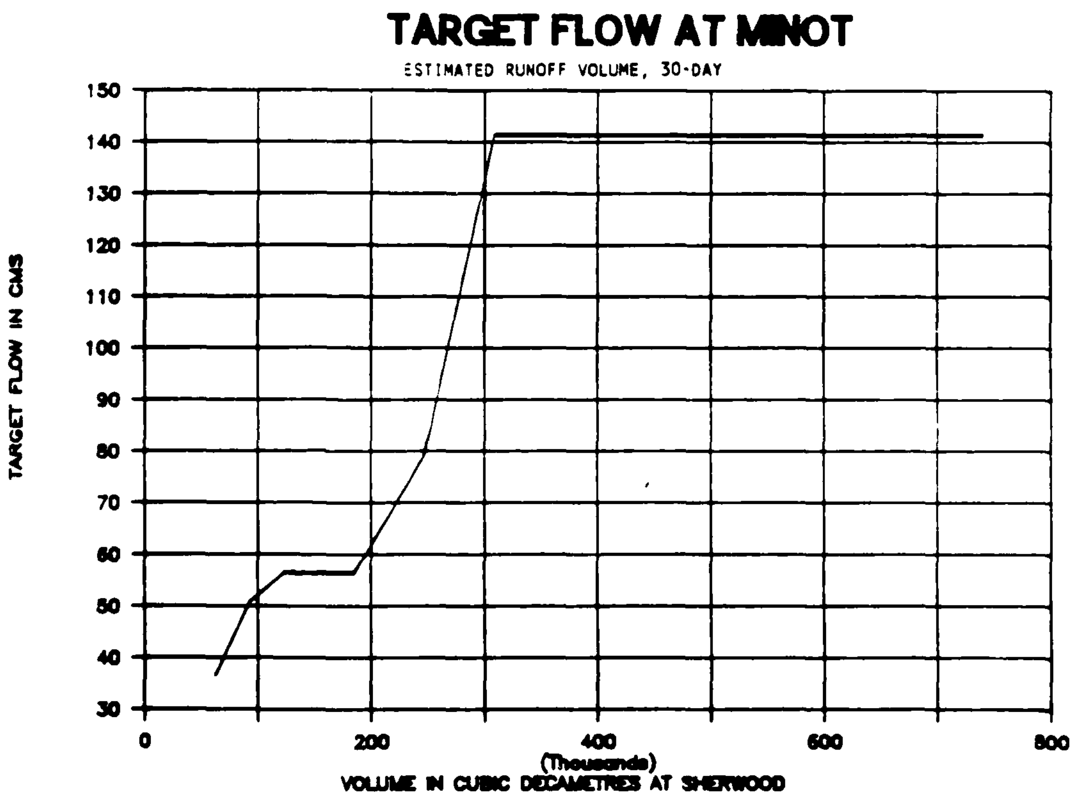
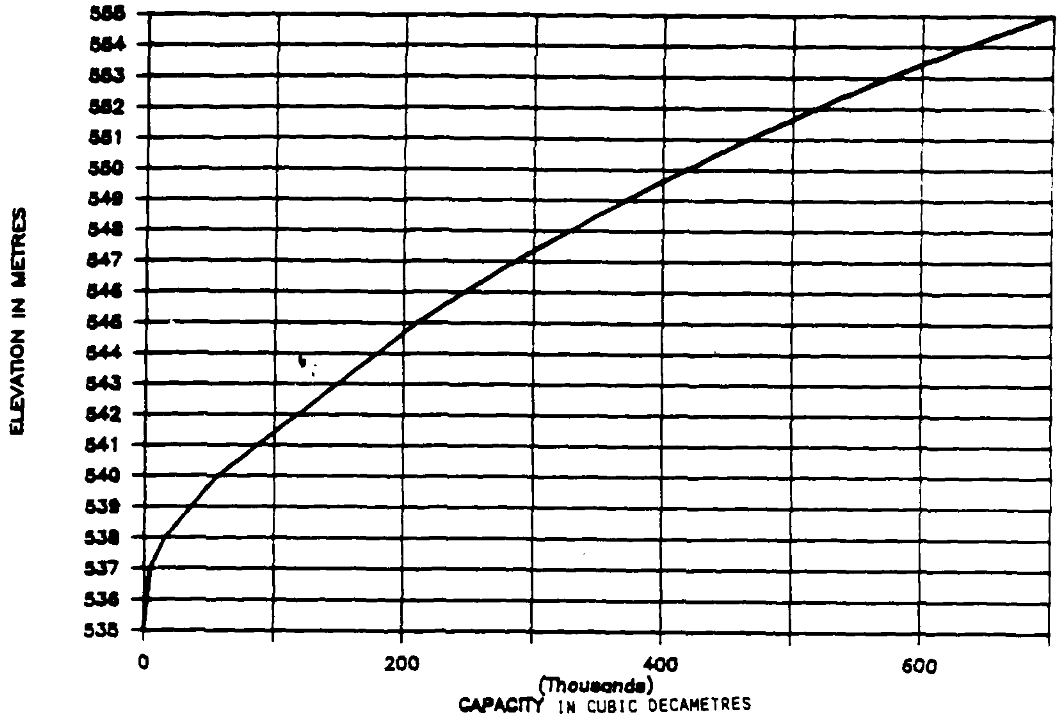

TARGET FLOW AT SHERWOOD
ESTIMATED RUNOFF VOLUME, 30-DAY
TARGET FLOW IN CMS
120
110
100
90
80
70
60
50
40
30
20
0
200
400
600
800
(Thousands)
VOLUME IN CUBIC DECAMETRES AT SHERWOOD

PLATE A-5


TARGET FLOW AT MINOT
ESTIMATED RUNOFF VOLUME, 30-DAY
TARGET FLOW IN CFS
(Thousands)
0
1
2
3
4
5
6
0
200
400
600
(Thousands)
VOLUME IN AC-FT AT SHERWOOD


TARGET FLOW AT MINOT
ESTIMATED RUNOFF VOLUME, 30-DAY
TARGET FLOW IN CMS
30
40
50
60
70
80
90
100
110
120
130
140
150
0
200
400
600
800
(Thousands)
VOLUME IN CUBIC DECAMETRES AT SHERWOOD

RAFFERTY ELEVATION–CAPACITY



RAFFERTY ELEVATION–AREA

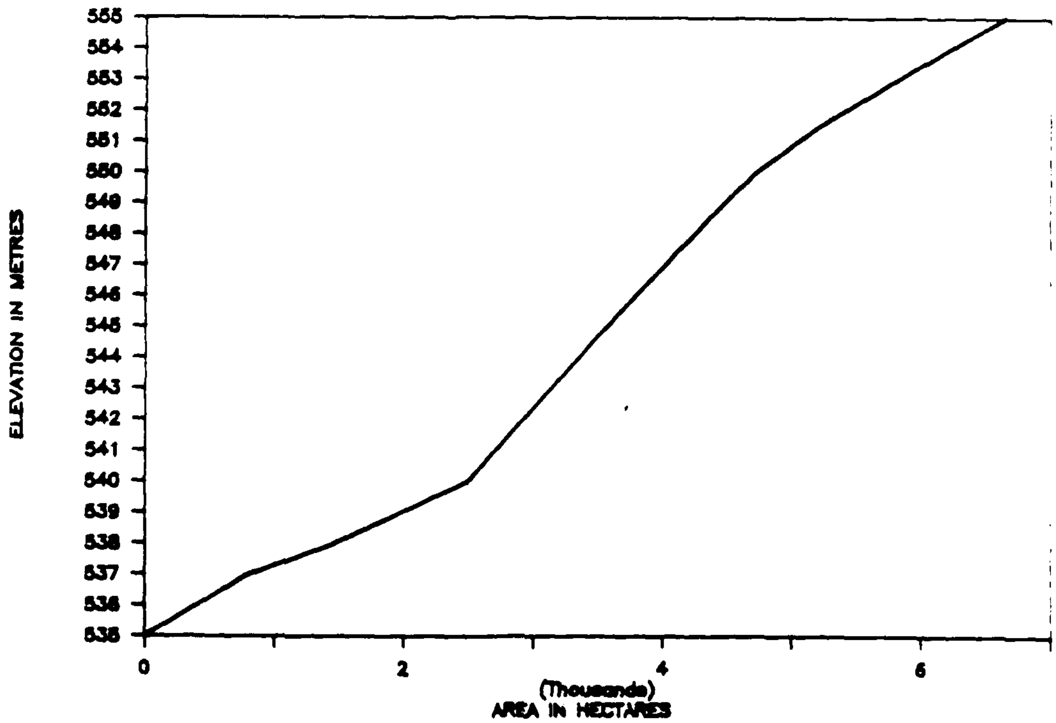
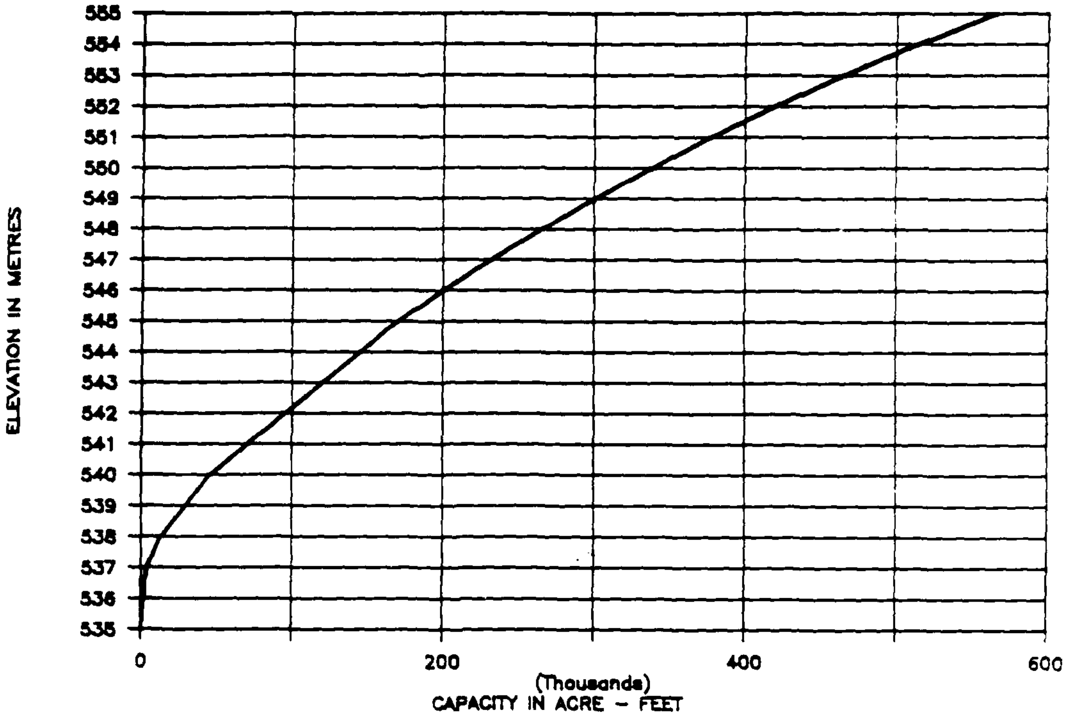


PLATE A–7A

RAFFERTY ELEVATION-CAPACITY



RAFFERTY ELEVATION-AREA

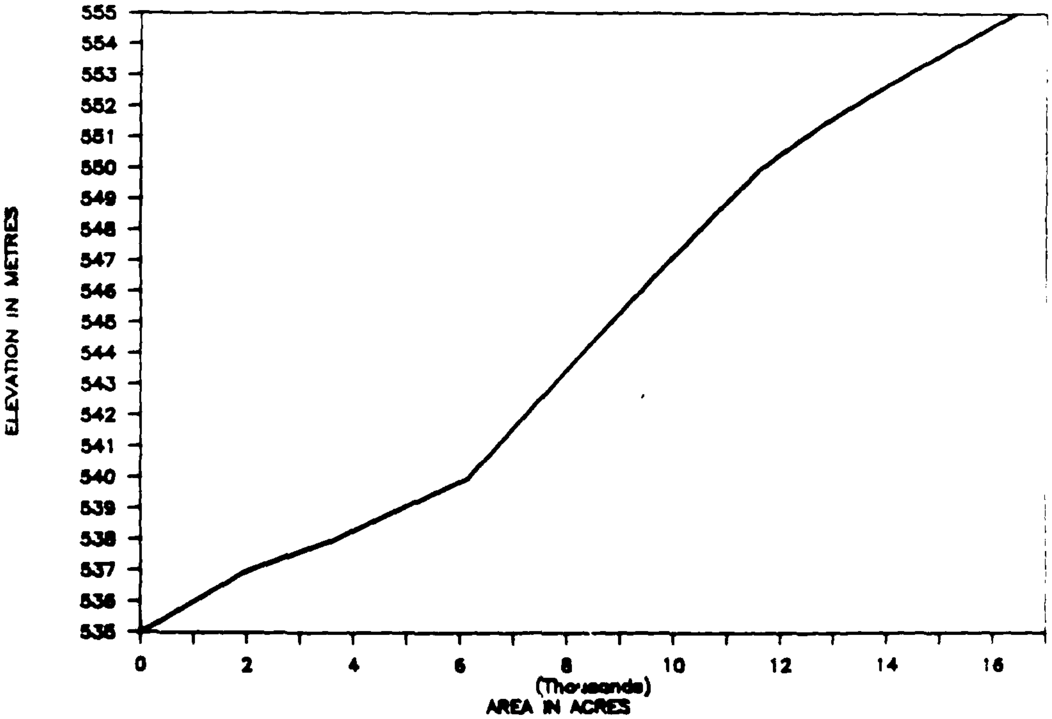
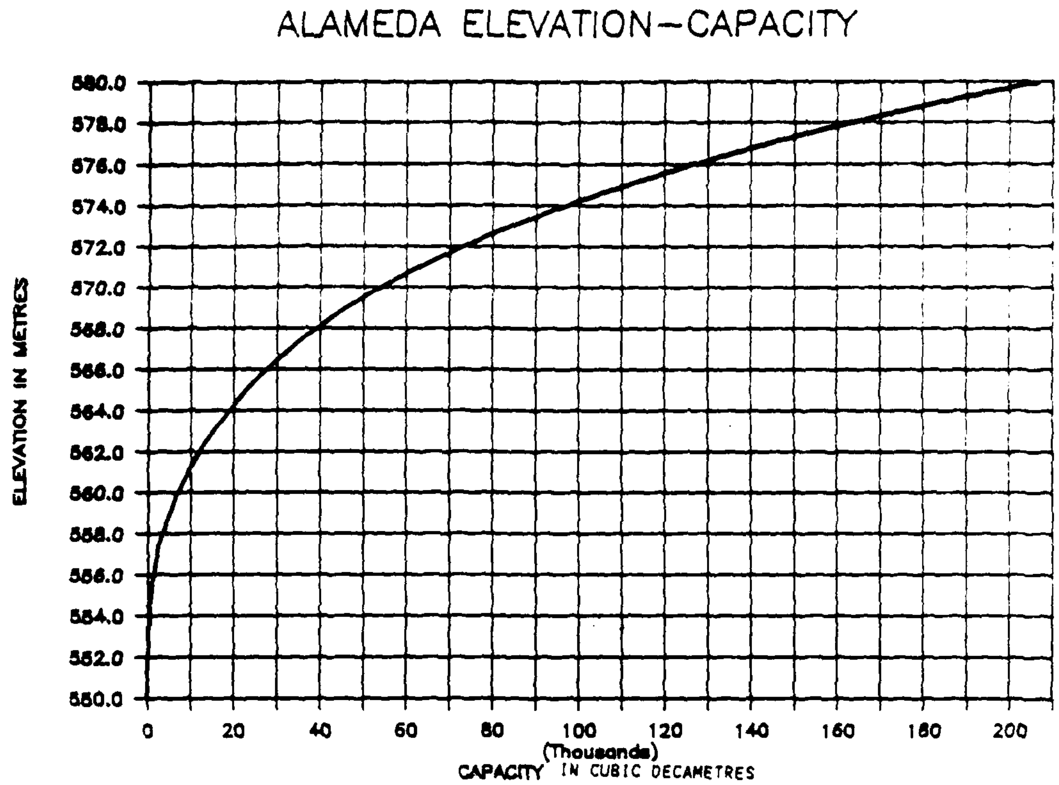


PLATE A-7B


ALAMEDA ELEVATION—CAPACITY
ELEVATION IN METRES
580.0
578.0
576.0
574.0
572.0
570.0
568.0
566.0
564.0
562.0
560.0
558.0
556.0
554.0
552.0
550.0
0
20
40
60
80
100
120
140
160
180
200
(Thousands)
CAPACITY IN CUBIC DECAMETRES

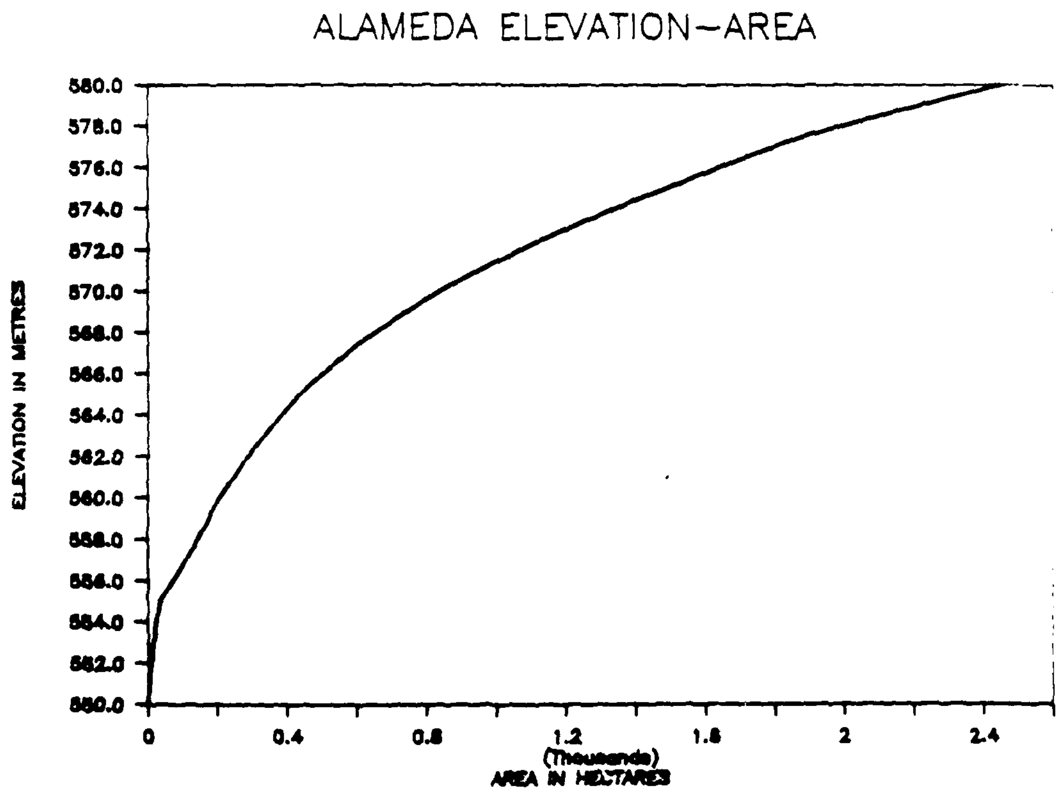
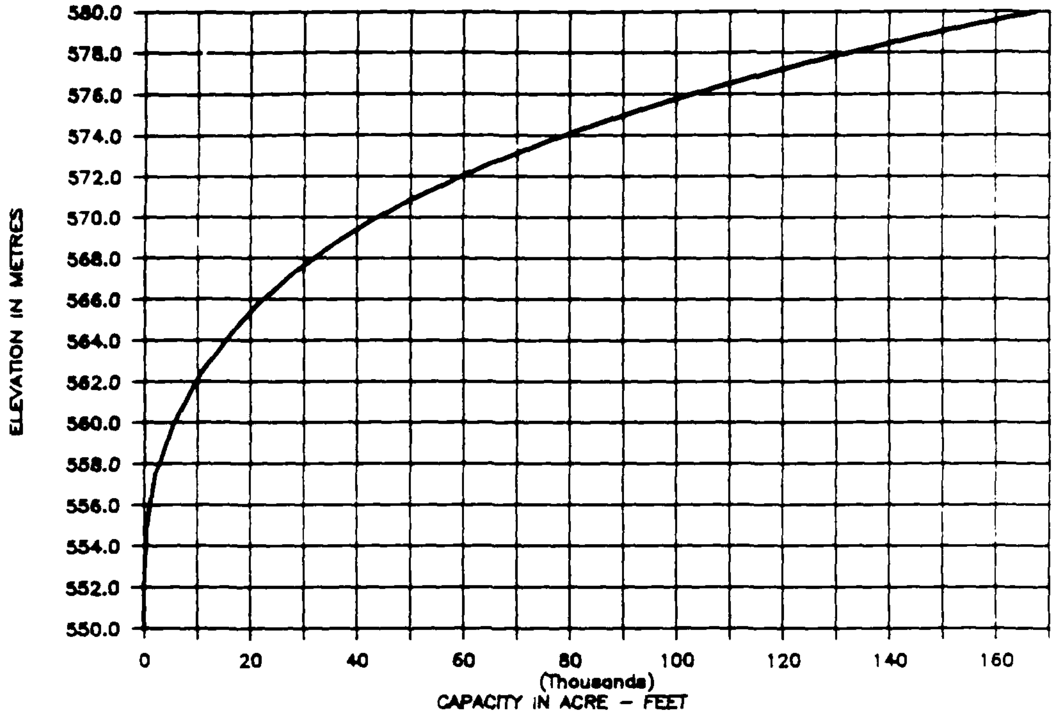

ALAMEDA ELEVATION—AREA
ELEVATION IN METRES
580.0
578.0
576.0
574.0
572.0
570.0
568.0
566.0
564.0
562.0
560.0
558.0
556.0
554.0
552.0
550.0
0
0.4
0.8
1.2
1.6
2
2.4
(Thousands)
AREA IN HECTARES

PLATE A-8A

ALAMEDA ELEVATION–CAPACITY



ALAMEDA ELEVATION–AREA

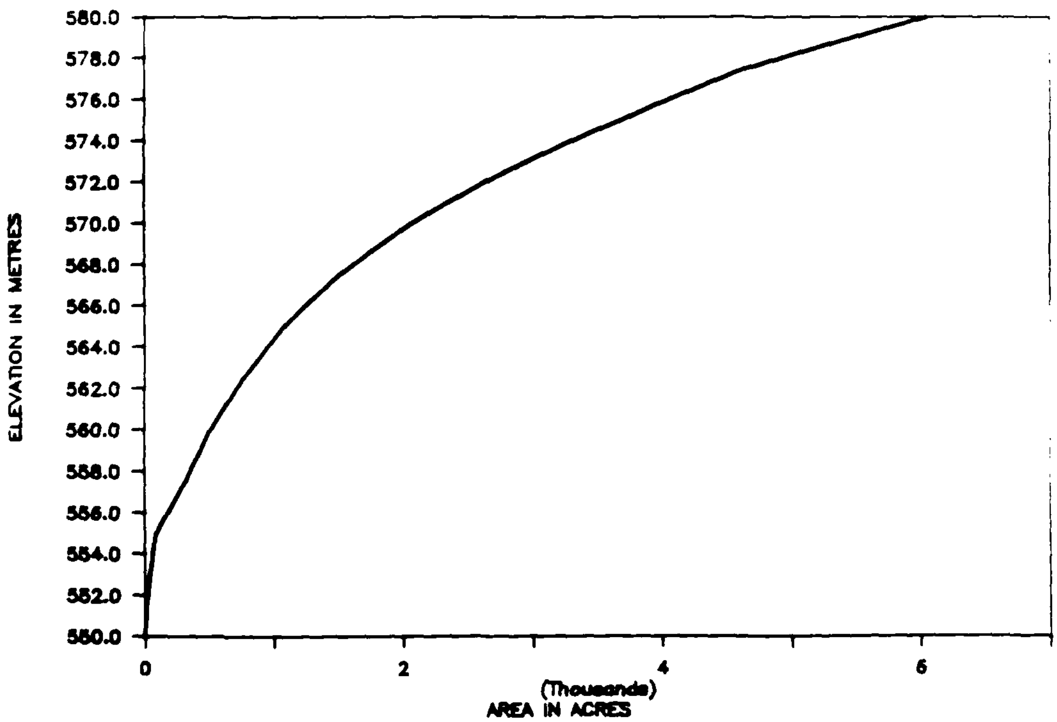
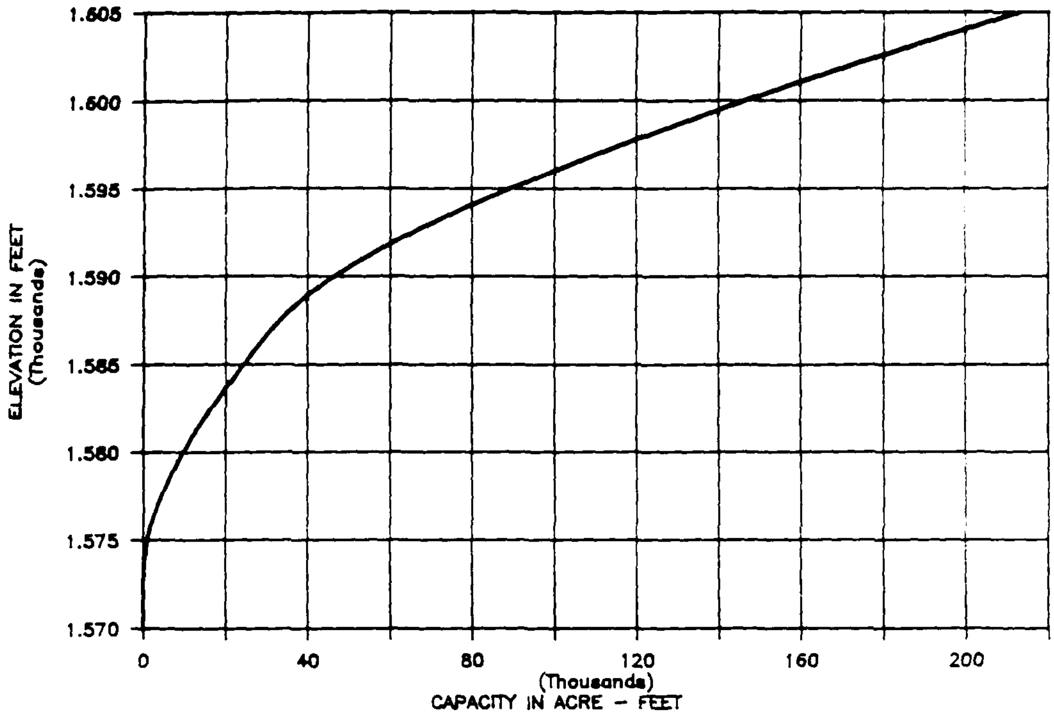


PLATE A–8B

LAKE DARLING ELEVATION—CAPACITY



LAKE DARLING ELEVATION—AREA

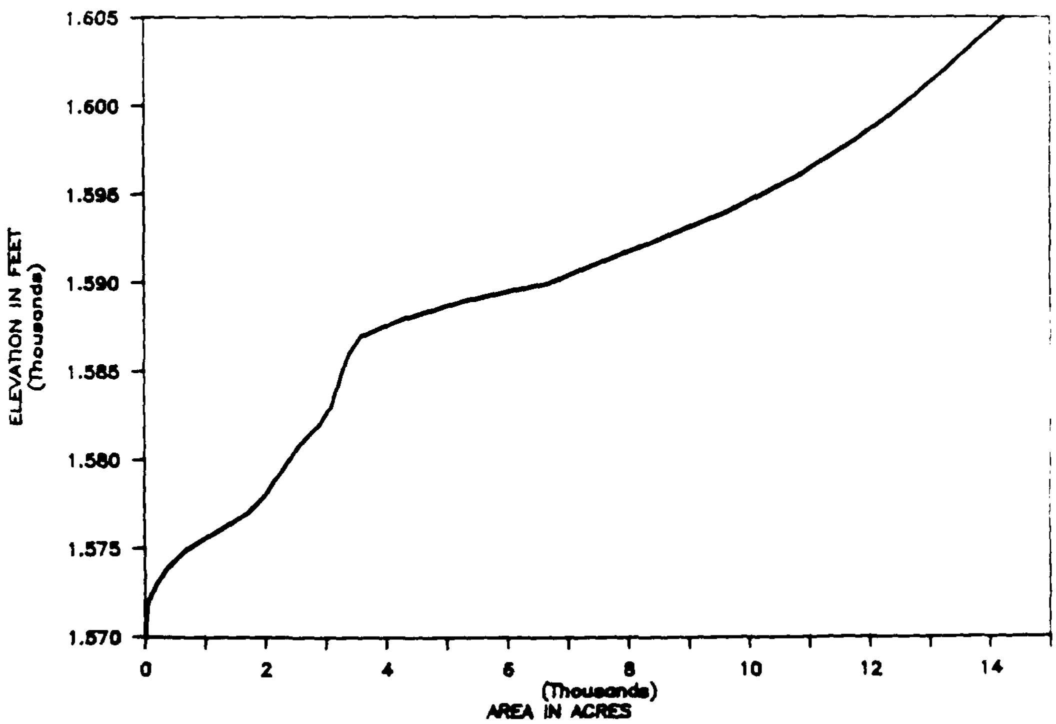
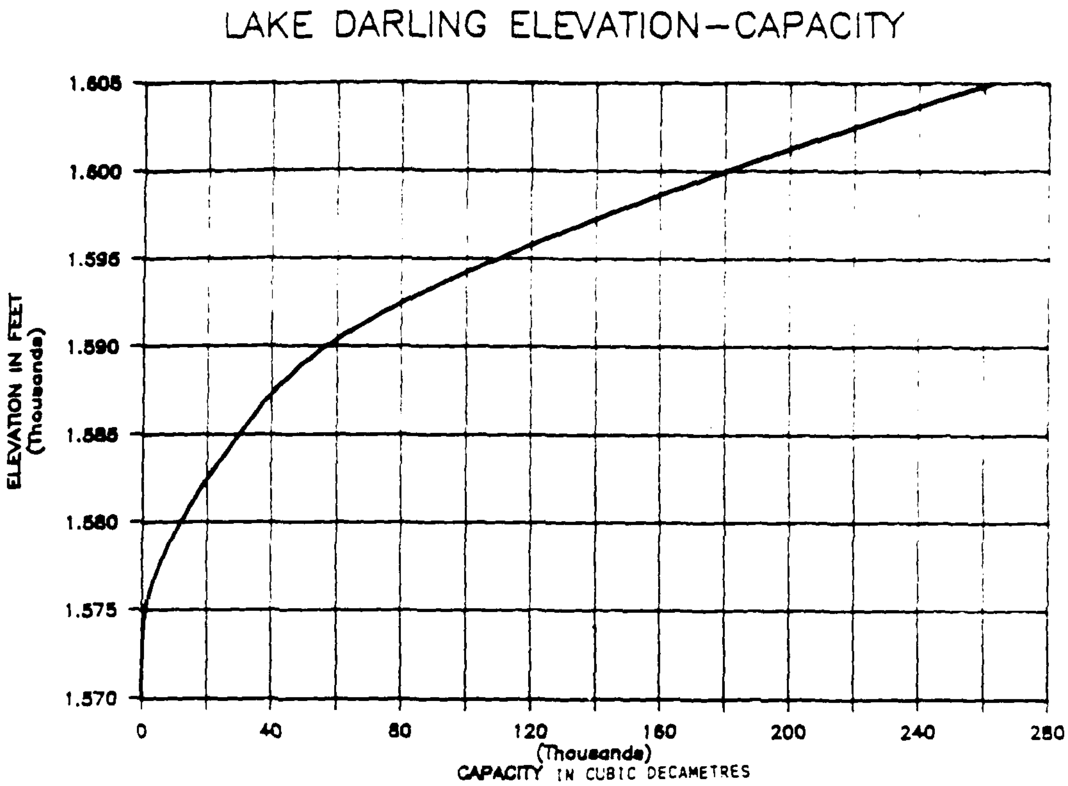


PLATE A—9A


LAKE DARLING ELEVATION—CAPACITY
ELEVATION IN FEET
(Thousands)
1.605
1.600
1.595
1.590
1.585
1.580
1.575
1.570
0
40
80
120
160
200
240
280
(Thousands)
CAPACITY IN CUBIC DECAMETRES

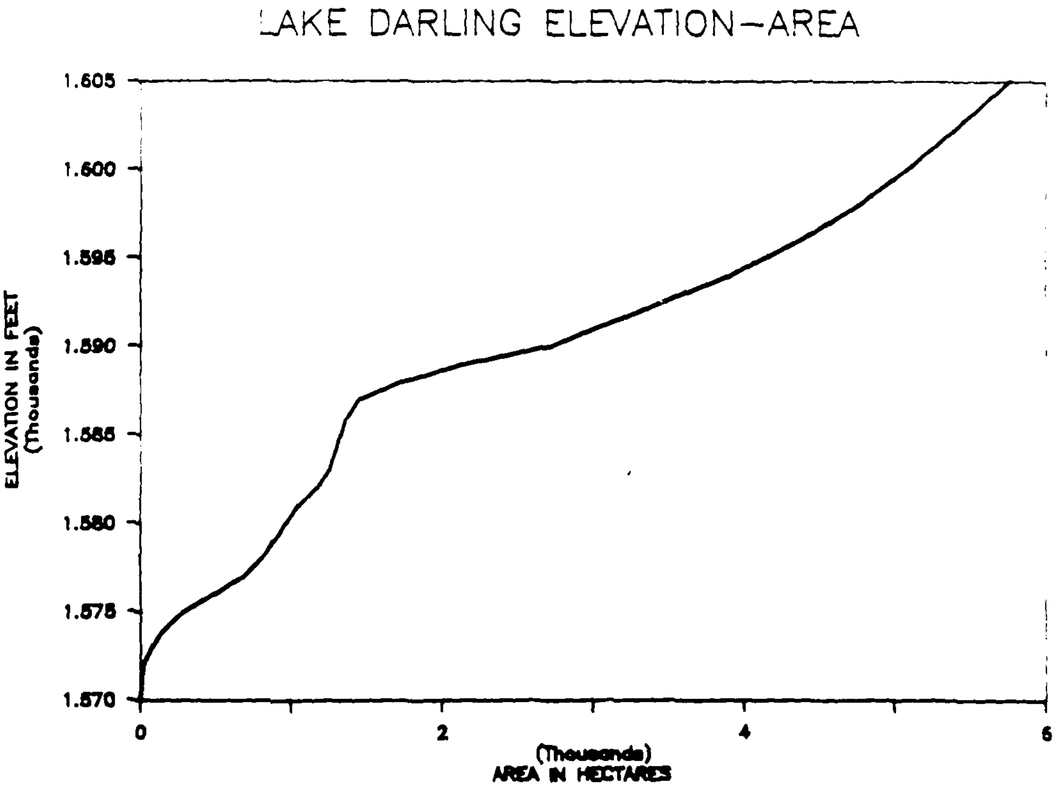

LAKE DARLING ELEVATION—AREA
ELEVATION IN FEET
(Thousands)
1.605
1.600
1.595
1.590
1.585
1.580
1.575
1.570
0
2
4
6
(Thousands)
AREA IN HECTARES

PLATE A-9B

DRAFT
ENVIRONMENTAL IMPACT STATEMENT
SOURIS BASIN FLOOD CONTROL PROJECT
SOURIS RIVER
RENVILLE, WARD, MCHENRY, AND
BOTTINEAU COUNTIES, NORTH DAKOTA

St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101
1987

P R E F A C E

The Souris River Basin flood control project is designed to provide flood protection at Minot, North Dakota, and other areas along the Souris River in North Dakota. This draft environmental impact statement focuses on the effects of project flood control features and their operation during flood events. Flood control features include: flood storage in Rafferty and Alameda reservoirs in Saskatchewan, Canada, modification of the outlet structures at Lake Darling Dam for flood operation, Burlington to Minot levees, and rural downstream measures. In addition, mitigation features will be provided to the U.S. Fish and Wildlife Service and compensation will be provided to Manitoba for any operational damages that occur from flood operation. The operation of water supply storages at Lake Darling Dam, Rafferty Dam, and Alameda Dam were not considered for study under the project authority and are not a part of this project.

Planning for flood control in the Souris River Basin has been ongoing for a number of decades. In more recent times, the Burlington Dam project is the starting point for a history of currently proposed actions. The Burlington Dam was authorized in 1970 as a means of providing flood protection for the city of Minot, North Dakota. Controversy concerning the Burlington Dam project led, at the request of people in the Souris River Basin, to a halt of Burlington Dam efforts and to the authorization of a 4-foot raise of the Lake Darling flood pool to provide 25-year flood protection at Minot (1982 Energy and Water Development Appropriations Act). The St. Paul District, U.S. Army Corps of Engineers (Corps) completed environmental impact statements for the Lake Darling project and attendant features in 1983 and 1985. The final EIS for the Lake Darling feature was filed with the Environmental Protection Agency (EPA) in February 1986.

During the same period that planning efforts in the United States were concentrating on flood control, similar efforts were underway in Saskatchewan for multipurpose water resource development focusing on water supply. In an effort to improve water management capabilities, Saskatchewan interests constructed Weyburn Dam in 1940 and Boundary Dam in 1958 and expanded the capacity above a new Weyburn Dam in 1983. In the late 1970's - early 1980's, planning efforts focused on a proposal to construct Rafferty Dam on the Souris River near Estevan, Saskatchewan, and Alameda Dam on Moose Mountain Creek near Alameda, Saskatchewan.

In March 1983, North Dakota and Saskatchewan interests established a North Dakota-Saskatchewan Boundary Advisory Committee (NDSBAC) for discussing matters of mutual concern. The areas of concern were primarily agriculture, water resources, economic development and tourism, and environmental protection. For many years, individuals, groups, and agencies had suggested that the "real solution" to the Souris River basin flood and related water resource problem was in a "total basin approach" involving a joint United States/Canada project.

In early 1984, with the recommendation of the NDSBAC, through the Saskatchewan Ministry of Economic Development and Trade and the Governor of North Dakota, a request was made for the Corps of Engineers to participate in a determination of the feasibility of using flood storage in Saskatchewan, Canada, for flood damage reduction in the United States. North Dakota interests pursued this matter through their congressional representatives. In August 1984, a resolution of the Senate Committee on Environment and Public Works authorized the Corps, in cooperation with Canada, to investigate the feasibility of Canadian multipurpose reservoirs in which the United States would purchase flood storage.

Since study authorization, discussions have taken place with Saskatchewan interests concerning the purchase of flood storage in two proposed reservoirs in the Souris River Basin in Canada (Rafferty and Alameda reservoirs). The principal United States participants in the discussions have been the State of North Dakota, the Corps of Engineers, the city of Minot, and the U.S. Fish and Wildlife Service. At the beginning of discussions, the Saskatchewan government officials indicated that they were on a tight schedule for the construction of Rafferty and Alameda reservoirs to provide cooling water for planned fossil fuel electric generating facilities. They indicated a need to have a United States commitment of interest by December 1985, to meet their construction schedule for Rafferty and Alameda Dams and the Shand power facilities.

In January 1985, the Corps of Engineers initiated a study which provided preliminary findings by July 1985 that flood storage in Saskatchewan was economically feasible. Further studies, in coordination with Saskatchewan and principal State and Federal agencies, indicated that providing 100-year protection at Minot, North Dakota, and substantially reduced flood damages along the Souris River in North Dakota was feasible. By an allocation of costs based on the Use of Facilities method of analysis, a United States contribution of $41.1 million was determined to be justified for storage in both Rafferty and Alameda reservoirs.

Following discussions with Saskatchewan on the benefits to the United States for flood storage in the Province, Saskatchewan agreed in principle in February 1986 to include flood storage for the United States in Rafferty and Alameda reservoirs. On 17 November 1986, Congress authorized the Souris River Basin Project to purchase flood storage in Rafferty and Alameda reservoirs and to provide compatible works in the United States. Further studies and discussions between Saskatchewan and principal agencies led to a 28 May 1987 agreement in principle to an operating plan for the project. Parties in the United States that signed the agreement included the North Dakota State Engineer (State Water Commission), the Souris River Joint Water Resource Board (United States project sponsor), the city of Minot, the U.S. Army Corps of Engineers, and the U.S. Fish and Wildlife Service.

The distribution of flow between the United States and Canada is monitored by the Souris River Board of Control and governed by the 1959 Interim Agreement between Governments as a result of the Boundary Waters Treaty of 1909. The interim agreement establishes that at least 50 percent of the natural runoff has to be delivered to the United States at Sherwood, North Dakota. The natural runoff is currently defined as the flow that would have occurred in a state of nature less contributions from previous noncontributing areas to include drainage from the Yellow Grass Ditch area and a pipeline diversion near Estevan, Saskatchewan.

The Souris River Basin is a semiarid region. Flood flows normally occur in the early spring as a result of snowmelt. During the remainder of the year, Souris River flows are usually very low. In the past, the Province of Saskatchewan has not had the capability to retain its 50 percent of natural runoff other than in the driest years. Historically, Saskatchewan has retained from 0 to 55 percent of the natural flows, with a long-term average retention of 15 percent. Since 1940, and as recently as 1983, Saskatchewan has been constructing facilities to increase its ability to retain its rightful share (50 percent) of Souris River Basin runoff. Saskatchewan's recent planning history and its need for water to sustain development in the southern area of the Province indicate the Province will continue to pursue construction of facilities to this end.

This draft environmental impact statement (DEIS) addresses the potential impacts of the flood control project upon environmental resources within the United States. This DEIS does not address project impacts within Canada. Those impacts are addressed in an environmental impact statement prepared by the Souris Basin Development Authority in compliance with Canadian laws and regulations. The Canadian EIS was released for public review in August 1987. The public review of that document is currently expected to be completed in December 1987. An important determination is what constituted the most probable future "without project" condition. From a planning perspective, this determination is significant because the most probable future "without project" condition is the base against which the effects of a proposed action are measured. The Corps of Engineers has determined that the most probable future "without project" condition is that, without United States participation, Saskatchewan interests would construct facilities to allow them to retain their 50 percent of Souris River Basin runoff with construction of Rafferty and Alameda reservoirs for water supply storage as the currently planned facilities. The probable impacts of construction and operation of these reservoirs for water supply purposes on United States resources are discussed as the most probable future "without project" condition.

Under the most probable future "without project" condition, a substantial change would occur to the water regime on the Souris River. Saskatchewan would retain the full 50 percent of its water from spring high flows when water is most abundant, and pass excess flood flows as they occurred without any storage. The retention of water during spring

high flows under the most probable future "without project" condition would not have a significant effect on flood flows in the United States, especially the large flood events, as Rafferty and Alameda reservoirs constructed for water supply only would not have the capacity to retain the water from these large events. Unregulated flows would enter the United States as in the past when they often cannot be used for beneficial purposes. In some years, that flow could constitute the United States allocation of water. Conversely, in nonflood years, Saskatchewan would have the capability to store water that could be made available to supplement low flow needs in the United States if the necessary agreements between Saskatchewan and North Dakota could be implemented.

A significant unknown concerning the most probable future "without project" condition is what impact the Saskatchewan reservoirs will have upon the quality of water entering the United States. This draft EIS uses the most current predictions available, based primarily upon studies done by Saskatchewan interests for their EIS and on discussions with the North Dakota Public Health Department. The North Dakota Public Health Department and State Water Commission have scheduled talks with Saskatchewan in November 1987 to discuss water quality issues. The U.S. Fish and Wildlife Service and the Environmental Protection Agency have agreed to participate in the meetings. Topics to be covered include thermal stratification, ammonia/dissolved oxygen, TDS/boron, nutrients, and mercury in fish. These talks may lead to further investigations. The Corps has been invited to attend these discussions as an observer. Based upon current information, the Corps believes that adding flood storage to the Saskatchewan reservoirs will not have a significant impact upon the quality of water entering the United States when compared to the most probable future "without project" condition.

There was not total agreement with the U.S. Fish and Wildlife Service in regard to some issues during the planning process. The U.S. Fish and Wildlife Service, in its Coordination Act Report, did not agree with the Corps basis for the most probable future "without project" condition, believing instead that without a United States contribution, Saskatchewan would not build Alameda and Rafferty reservoirs for water supply storage. That is, the dams would not be built and the United States would continue to receive Souris River flows from Saskatchewan in quantity and quality similar to what has occurred in the past. In recent discussions, the U.S. Fish and Wildlife Service has acknowledged, based on current more detailed Saskatchewan actions toward construction and past development within the Province, that for the purposes of this EIS the Corps basis for the most probable future "without project" condition is appropriate. The Corps has also acknowledged that the final EIS may include impacts not directly attributable to the project regardless of the perspective of the "without project" condition.

It is important that reviewers of this document recognize that Saskatchewan can proceed to construct dams for multipurpose water use within the Province, as long as the water retained each year meets the apportionment at the United States border, without any environmental

documents being prepared by any United States agency. The State of North Dakota and the U.S. Fish and Wildlife Service recognize this important item. The State of North Dakota is working with the Province to address these concerns. The purchase of flood storage by the United States on top of the water supply storage and the operation of the Souris River Basin project for flood control purposes are the actions addressed in this EIS. The resulting environmental, sociological, and economic impacts are identified in this EIS.

The action to provide flood storage in Saskatchewan to reduce damages in the United States will provide an added benefit as the stored water is released. Without the storage, excess water from moderate flood events would enter the United States at times when it could not be totally or beneficially used. With storage, water could be released when it could best be used within the United States.

DRAFT
ENVIRONMENTAL IMPACT STATEMENT
SOURIS BASIN FLOOD CONTROL PROJECT
SOURIS RIVER,
RENVILLE, WARD, MCHENRY, AND
BOTTINEAU COUNTIES, NORTH DAKOTA

The responsible lead agency is the U.S. Army Corps of Engineers District, St. Paul, Minnesota. The responsible cooperating agency is the U.S. Fish and Wildlife Service.

Abstract - The purpose of this document is to analyze the environmental impacts of providing flood protection in the Souris River basin through storage of floodwater in Saskatchewan, Canada, and construction of compatible Lake Darling project features in the United States. The proposed plan would provide protection from the 100-year flood at Minot through simultaneous regulation of water levels in Lake Darling and two proposed reservoirs in Saskatchewan. The dams in Saskatchewan are being planned to provide water supply in Canada. The U.S. would contribute funds to build these dams higher so that they would also provide flood protection for the U.S. portion of the basin.

Primary impacts of the proposed project (flood protection using storage of water in Canada) stem from alteration of flows in the Souris River. During non-flood periods less water would be delivered to North Dakota due to an "evaporation sharing agreement" which would be instituted as a part of the project. During flood years peak flows would be reduced and durations would be prolonged as a result of the flood operation plan. Major impacts associated with the project include changes in floodplain vegetation, loss of wildlife use of habitat during prolonged inundation, reduced habitat management capabilities on two National Wildlife Refuges, losses of wetland vegetation, potential declines in the Lake Darling fish resource, and changes in wildlife populations resulting from vegetation impacts. Many of the potential impacts are similar to those associated with the earlier Lake Darling Four-Foot Raise project because the proposed operation plan downstream of Lake Darling is similar to that of the Lake Darling project. The proposed fish and wildlife mitigation plan is also similar to the plan developed for the Lake Darling study.

If you want further information on this EIS, please contact:

Mr. Charles E. Workman
U.S. Army Engineer District, St. Paul
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101-1479
FTS telephone: 725-7745
Commercial telephone: (612) 725-7745

Send your comments to the District Engineer within 45 days of the notice in the Federal Register. The notice should appear within 1 or 2 weeks after the initial mailing of this EIS.

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1.0 SUMMARY

Major Findings and Conclusions

1.01 The Souris Basin flood control project is authorized by the Water Resources Development Act of 1986 (PL 99-662). The authorization directs the Corps of Engineers (COE) to study and to participate in construction of reservoir projects in the Canadian Province of Saskatchewan and flood damage reduction measures in the United States. The objective of the project is to provide 100-year flood protection for the city of Minot.

1.02 Two plans were studied during project planning: a) the Souris Basin plan which would provide 100-year protection through storage of floodwater in Canada; b) the Lake Darling plan which would provide 25-year protection with a four-foot raise of the lake. Economic, engineering and environmental analyses of these plans concluded that the Souris Basin plan should be recommended as the best solution to flooding problems along the Souris River. The Souris Basin plan is environmentally preferrable because it has less impact on the resources of the United States. Both plans have the same net benefits, but the Souris Basin plan was selected because it offers 100-year protection for the city of Minot.

1.03 The environmental analysis found that the selected plan complies with all applicable environmental laws and regulations. Laws and regulations especially important to the planning of this project include E.O. 11990 (Protection of Wetlands), E.O. 11988 (Prevention of Floodplain Development), E.O. 12114 (Environmental Effects Abroad of Major Federal Actions), and the Endangered Species Act.

1.04 The purchase of flood storage would not have any effects on resources of global importance and is therefore in compliance with E.O. 12114. Construction of reservoirs in Saskatchewan would have significant adverse impacts on Canadian natural resources, however these impacts are not discussed in this document because they are not attributable to the purchase of flood storage. Impacts associated with construction of the dams in Saskatchewan are discussed in environmental impact statements prepared by the Souris Basin Development Authority. The Canadian EIS is available from the Souris Basin Development Authority, 814-4th Street, Estevan, Saskatchewan, Canada, 54A 0V9.

1.05 The environmental analysis also found that the primary impacts of the proposed project are a direct result of the altered hydrologic conditions, especially the altered flood flows. Most of the impact occurs in the Souris River floodplain where releases of stored floodwaters impact floodplain vegetation and wildlife use of these habitats; and on the J. Clark Salyer National Wildlife Refuge where management capabilities would be disrupted during prolonged discharge of floodwater and wetland values would be lost.

Areas of Controversy

1.06 Control of flooding on the Souris River is greatly desired locally, especially in Minot. However, past proposals for flood control have met with opposition, due to some negative consequences outside of Minot. The Souris Basin project by storing water outside of the U.S., eliminates or displaces to Saskatchewan many of the grounds for controversy.

1.07 Comments received during project planning indicate there are outstanding issues which could become controversial during public review of this document. These issues include regional impacts occuring in Saskatchewan which are of concern to U.S. environmental interests, the perception or reality of lower river flows for North Dakota during drought years, and the effects of operating releases on agricultural lands and the National Wildlife refuges. Although these issues have been extensively coordinated with representatives of the State, Federal, and Canadian government, they have not been fully coordinated with the affected publics due to ongoing negotiations with Canadian officials regarding the specifics of the low-flow and flood operation plans; hence, the degree of controversy, if any, will be unknown until public meetings are held (see paragraph 6.03).

Unresolved Issues

1.08 An unresolved issue involves the amount of payment to Manitoba for damages from floodwater releases from Lake Darling. The Lake Darling Four-Foot Raise project included a one-time payment of $200,000 for these damages. Manitoba has since indicated that this amount of money is inadequate; hence, further discussion and study are needed to determine acceptable compensation.

Relationship to Environmental Requirements

1.09 The proposed project fully complies with applicable environmental protection statutes and Executive Orders for the current stage of planning (table 1). Environmental statutes and Executive Orders important to the decision on this project include the National Environmental Policy Act of 1969, the Water Resources Planning Act of 1965, the Fish and Wildlife Coordination Act of 1958, the Endangered Species Act of 1973, the Land and Water Conservation Fund Act, the Archeological and Historic Preservation Act, Executive Order 11988 on Floodplain Management, Executive Order 11990 on Protection of Wetlands, and Executive Order 12114 on Environmental Effects Abroad of Major Federal Actions.

1.10 The proposed action also complies with Section 404 of the Clean Water Act as a result of analyses conducted for the Lake Darling 4-foot raise project and water quality certification received from the State of North Dakota (Appendix 7). The proposed plan differs from the Lake Darling project in that it eliminates the requirements to place fill in some areas (e.g., Dam 41), and would require placement of less fill in other areas (e.g., Lake Darling Dam). It does not require placement of fill material in any additional areas and is therefore in compliance with the Act. The purchase of flood storage in Canadian reservoirs, in and if itself, is not an activity requiring water quality certification.

Further Studies

1.11 Further cultural resources studies are planned. These include: 1) survey and testing of sites located in the area from the Canadian border to that area which was previously surveyed for the Lake Darling project; 2) survey and testing of sites that may be located in the borrow areas necessary for construction of facilities around Lake Darling Dam and fish and wildlife mitigation measures downstream of the dam.

1.12 Representatives of Saskatchewan and North Dakota are currently holding discussions concerning the potential water quality effects of the construction and operation of Rafferty and Alameda reservoirs for water supply. The Corps of Engineers has been invited to attend these discussions as an observer. These discussions may lead to further water quality studies that could enhance the ability to predict future without project water quality conditions.

2.00 NEED FOR AND OBJECTIVES OF ACTION

Project Background

2.01 The Souris Basin project is the third phase of flood control studies for the Souris Valley in North Dakota. The channel modification in Minot, which was authorized in 1970 and completed in 1979, was the first phase of construction. The Velva levee project, which was authorized in 1982 and scheduled for completion in 1987, is the second phase of construction. In 1970, the Burlington Dam project was authorized as the third phase of the flood control plan, however, much controversy developed which eventually prompted Congress to direct the Corps of Engineers (COE) to study provision of flood protection with a four-foot raise of Lake Darling and defer constructing Burlington Dam. In 1984 a Senate committee adopted a resolution authorizing the COE to investigate the feasibility of purchasing flood storage at proposed reservoirs in Saskatchewan, Canada. Based on studies completed in September 1986, the COE recommended further investigation of the Souris Basin project which calls for purchase of flood control storage in Canada, modification of the gated outlet of Lake Darling Dam, and downstream flood control measures. The proposed project was authorized by Congress in the Water Resources Development Act of 1986 (Public Law 99-662).

2.02 To date, the following environmental documents related to flood control in the Souris Basin have been produced:

a) Draft and Final Environmental Impact Statements covering flood control through construction of the Burlington Dam. (St. Paul District 1978)

b) Draft and Final Programmatic Environmental Impact Statements covering a general program for flood control along the Souris River including a four-foot raise of Lake Darling, a variety of features to protect homes and roads adjacent to the river, and construction of levees at Velva, Sawyer, and six subdivisions between Burlington and Minot. (St. Paul District 1983)

c) DRAFT AND FINAL FEATURE ENVIRONMENTAL IMPACT STATEMENTS FOR THE FOUR-FOOT RAISE OF LAKE DARLING. (ST. PAUL DISTRICT 1985) THIS DOCUMENT IS INCORPORATED BY REFERENCE INTO THIS ENVIRONMENTAL STATEMENT AS A SOURCE OF MATERIAL ON PROJECT HISTORY AND ON THE IMPACTS OF THE LAKE DARLING 4-FOOT RAISE PROJECT. COPIES ARE AVAILABLE UPON REQUEST FROM THE ST. PAUL DISTRICT.

Study Authority

2.03 Current authorization for the Souris Basin project is included in the 1986 Water Resources Development Act, Public Law 99-662, which was signed on 17 November 1986. The following is an extract from that authorization (full authorization is given in the attached General Plan Report):

Table 1
Relationships of the Proposed Plan to Environmental Requirements

Federal Statutes	Lake Darling Plan	No Action	Souris Basin Plan
Archaeological and Historic Preservation Act, as amended, 16 U.S.C. 469, et seq.	Full	N/A	Full
Clean Air Act, as amended, 42 U.S.C. 7401, et seq.	Full	Full	Full
Clean Water Act, as amended (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	Full	Full	Full
Coastal Zone Management Act, as amended, U.S.C. 1451, et seq.	N/A	N/A	N/A
Endangered Species Act of 1973, as amended, 16 U.S.C. 1531, et seq.	Full	Full	Full
Estuary Protection Act, 16 U.S.C. 1221, et seq.	N/A	N/A	N/A
Federal Water Project Recreation Act, as amended, 16 U.S.C. 460-1(12), et seq.	Full	Full	Full
Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661, et seq.	Full	Full	Full
Land and Water Conservation Fund Act, as amended, 16 U.S.C. 4601-11, et seq.	Full	Full	Full
Marine Protection, Research and Sanctuaries Act, 22 U.S.c. 1401, et seq.	N/A	N/A	N/A
National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321, et seq.	Full	Full	Full
National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470a, et seq.	Full	N/A	Full
National Wildlife Refuge System Administration Act, of 1966, 16 U.S.C. 668dd-ee, as amended.	Full	Full	Full
Rivers and Harbors Act, 33 U.S.C. 401 et seq.	N/A	N/A	N/A
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	N/A	N/A	N/A
Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1001, et seq.	N/A	N/A	N/A
Farmland Policy Protection Act of 1981	N/A	N/A	N/A
Executive Orders, Memoranda			
Floodplain Management (E.O. 11988)	Full	Full	Full
Protection of Wetlands (E.O. 11990)	Full	Full	Full
Environmental Effects Abroad of Major Federal Actions (E.O. 12114)	Full	N/A	Full
Analysis of Impacts on Prime and Unique Farmlands, CEQ Memorandum 30 August 1976	Full	Full	Full
State and Local Policies	Full	Full	Full
Land Use Plans	Full	Full	Full

Notes: The compliance categories used in this table were assigned according to the following definitions.

a. Full compliance - All requirements of the statute, EO, or other policy related regulations have been met for the current stage of planning.

b. Partial compliance - Some requirements of the statute, EO, or other policy and related regulations remain to be met for the current stage of planning.

c. Noncompliance - Violation of a requirement of the statute, EO, or other environmental requirement.

d. Not applicable (N/A) - Statute, EO, or other policy not applicable for the current stage of planning.

(1) See Cultural Resources Impacts Section for a discussion of compliance on a feature by feature basis and for a discussion of work to be accomplished to achieve compliance with regulations.

> Sec. 332. (a)(1) On behalf of the United States, the Secretary (of the Army), in consultation with the Secretary of State, is authorized to cooperate with governments in Canada to study and to construct reservoir projects for storage in the Souris River basin in Canada to provide flood control benefits in the United States.

The authorization also contains funding limitations ($41,100,000 for purchase of storage in Canada and $69,100,000 total cost), a provision to deauthorize the Burlington Dam and the 4-foot raise of Lake Darling dam if the Canadian dams are constructed, and the authority to make modifications to Lake Darling (exclusive of a four-foot raise) to make it an effective part of the flood control project.

Public Concerns

2.04 The major concern expressed by Minot residents is the need for flood damage reduction and protection of public health and safety during floods on the Souris River and its tributaries. Although Minot is afforded protection from the 16-year flood by the existing channel modification project, the potential for damages from larger floods is still great. Not only are urban areas such as Minot, Velva, Sawyer, and 6 subdivisions subject to flood damages, but rural residents in the Souris Valley suffer both damage to structures and crop delays caused by flooding.

2.05 At the outset of the environmental analysis, views from concerned agencies and individuals were solicited so that critical environmental issues could be identified and addressed in the environmental impact statement. The following is a summary of the issues which were identified (copies of the letters received are included in appendix 2).

a) Effects of the project on Cultural Resources in Canada (North Dakota State Historical Society)
b) Impacts to natural resources in Canada (National Wildlife Federation).
c) Impacts and alternatives to water cooled power generation in Saskatchewan (National Wildlife Federation).
d) Altered benefit/cost ratios for downstream levees due to the proposed 100-year protection (National Wildlife Federation).
e) Water supply to the "Eaton flood project" (Johnathon C. Eaton).
f) Future without-project conditions should be the same as existing conditions (Fish and Wildlife Service).
g) Hydrologic models should consider both water supply and flood flows (Fish and Wildlife Service).
h) Effects of prolonged releases during the 50 and 100-year floods (Fish and Wildlife Service).
i) Effects on the waterfowl and water supply functions of Lake Darling (Fish and Wildlife Service).
j) The EIS should provide a good description of future without-project conditions (Environmental Protection Agency).
k) The EIS should contain a good assessment of the no-action, four-foot raise, and Canadian storage alternatives (Environmental Protection Agency).

All of these issues have been addressed at various points in this EIS.

Planning Objectives

2.06 The primary planning objective identified in the United States in North Dakota is to:

> Reduce flood damages along the Souris River in the United States to reduce local, State, and Federal flood damage costs during the 1990-2090 period of analysis.

2.07 In conjunction with the primary objective, other planning objectives are to:

- o Contribute to fish and wildlife resources of the Souris River basin to protect or enhance this resource for the 1990-2090 period of analysis.
- o Contribute to the water supply resources of the Souris River basin to help meet current and future water supply demands for the 1990-2090 period of analysis.
- o Contribute to the improvement and/or conservation of water quality of the Souris River in the Souris River basin to protect or enhance water quality for the 1990-2090 period of analysis.
- o Contribute to recreation of the Souris River basin to help meet current and future recreation demands for the 1990-2090 period of analysis.
- o Contribute to the social, cultural, aesthetic, and historical resources in the Souris River basin to preserve and enhance these values for the 1990-2090 period of analysis.
- o Contribute to the security and welfare of the State of North Dakota and the United States to preserve and enhance the overall social well-being for the 1990-2090 period of analysis.

Planning Constraints

2.08 Saskatchewan's priority to have Rafferty Dam under construction by the spring of 1988 and requirement for a United States commitment to support the flood control cost of the project allow little time for normal U.S. planning, authorization, appropriation, and financing procedures. A special United States planning effort to meet Saskatchewan's schedule will be required from Federal, State, and local agencies and interests to implement the project as scheduled. Without this effort, an opportunity for achieving 100-year protection at points along the Souris River in North Dakota would be lost. Interim reports and actions may be required to separate project features in Saskatchewan and features in the United States to meet Saskatchewan's schedule.

3.00 ALTERNATIVES

PLANS ELIMINATED FROM FURTHER STUDY

3.01 Through the numerous flood damage reduction plans for the Souris River Basin have been identified and considered. These plans included floodplain

evacuation, construction of a dam at Burlington, North Dakota, diversion of floodwater along the Canada-U.S. border, construction of levees around the flooded cities, routing floodwater through a tunnel under Minot, construction of a larger Lake Darling dam, and various combinations of these plans. Detailed descriptions of eliminated plans and reasons for their elimination are given in the Lake Darling Four-Foot Raise EIS.

NO ACTION

3.02 Under the no action alternative, no further flood control measures on the Souris River would be implemented. This alternative would not change existing flood protection features at Minot and Velva, but would eliminate other flood protection measures which are at various stages of planning and implementation (e.g., the Burlington to Minot improvements, Sawyer levees, rural downstream measures, upgrading of refuge structures, raising of the Lake Darling Dam, and purchase of flood control in Saskatchewan). The no action alternative also assumes that the province of Saskatchewan would construct Rafferty and Alameda dams. However, the dams would be constructed for water supply in Canada and would not provide flood control benefits in North Dakota (refer to paragraph 4.72 for a more detailed discussion of the implications of this future without assumption).

3.03 THE NO ACTION ALTERNATIVE IS NOT A FEASIBLE ALTERNATIVE BECAUSE THE CONGRESSIONAL AUTHORIZATION FOR THIS STUDY REQUIRES EITHER PURCHASE OF FLOOD CONTROL IN CANADA OR THE RAISE OF LAKE DARLING FOR THE PURPOSE OF FLOOD CONTROL. THE NO ACTION ALTERNATIVE PROVIDES A BASELINE AGAINST WHICH TO COMPARE THE TWO ALTERNATIVE PLANS.

LAKE DARLING PLAN

3.04 The Lake Darling plan includes a 4-foot raise of Lake Darling plus other flood control measures upstream and downstream of the Lake Darling dam. It is the same plan recommended in the Lake Darling EIS. Total costs would be $63,687,000, with a benefit-cost ratio of 1.77 at a 5 1/8 percent interest rate. Authorization for the current study dictates that the Lake Darling plan is to be pursued only if the Souris Basin plan is infeasible (see paragraph 2.03).

3.05 The Lake Darling plan is comprised of the following features (detailed descriptions are provided in the Lake Darling 4-foot raise EIS.

Feature A: Raise Lake Darling Dam - Lake Darling dam would be raised 4 feet so that flood water could be stored behind the dam. The additional storage would protect Minot from all floods smaller than the 25-year event. Occasional storage of flood water behind the raised dam would also require purchrse of flowage easements on approximately 1180 acres of privately owned land.

Feature B: McKinney Cemetery Levee - of flood water behind Lake Darling dam would occasior .nundate McKinney Cemetery. In order to prevent damages a levee would be constructed on the riverward side of the ceme ry.

Feature C: Renville County Park - This residential area at the upstream end of Lake Darling would be protected from flooding by a levee and modification of the Souris River channel.

Feature D: Eckert Ranch - A group of farm buildings on the east side of Lake Darling would be protected with a levee.

Feature E: Downstream Urban Levees - Levees would be constructed around eight urban areas to provide protection from the flood water releases from Lake Darling. The urban areas include Johnson's Addition, Brook's Addition, Tabbot's Nursery, Country Club Acres and Robinwood Estates, Kings Court and Rostad's Addition, Tierrecita Vallejo, Sawyer, and Velva. The levees at Velva are currently being constructed, and other levees are undergoing advanced engineering and design.

Feature F: Downstream Rural Measures - Numerous rural residences would be provided flood protection through relocation out of the floodplain, flood proofing measures, or construction of levees.

Feature G: Gassman Coulee Flood Warning - A flood warning, system would be installed at Gassman Coulee to provide the police or fire department enough time to evacuate the portions of Minot which would be damaged by a flood from this coulee.

Feature H: Refuge Features - Many of the dams, roads, trails, and boat launch facilities on the Upper Souris refuge would have to be upgraded in order to ensure their continued operational capabilities during the controlled release of flood water (refer to table 2).

Feature I: Carp Control Structure - A carp control structure would be installed below dam 357 to ensure that the controlled release of flood water did not enable carp to become established in the U.S. portion of the Souris Basin.

3.06 Another important part of the Lake Darling plan is the schedule for release of flood water stored behind the Lake Darling dam. Development of a floodwater release plan required careful coordination among those affected by the releases. Major factors influencing the development of a flood operation plan included: the levees at Minot are designed to withstand flows of 5000 cfs; large tracts of agricultural land adjacent to the river cannot be used unless flows are below approximately 500 cfs by 1 June; J. Clark Salyer NWR cannot perform required management activities unless flows are below 150 cfs by 15 June. The agreed-upon flood operation plan calls for maximum releases to be less than 5,000 cfs prior to 15 May, less than 2,500 cfs between 15 May and 1 June, and below 500 cfs after 1 June.

SOURIS BASIN PLAN

3.07 The basis of the Souris Basin Plan is that flood protection for the city of Minot could be provided with storage of floodwater in Saskatchewan. The plan would enable 100-year protection for Minot without a raise of the Lake Darling Dam. The four aspects to this plan (Canadian storage of floodwater, flow releases from Canada, regulated flow releases from Lake Darling, and the

PLATE 1:

SOURIS RIVER BASIN STUDY

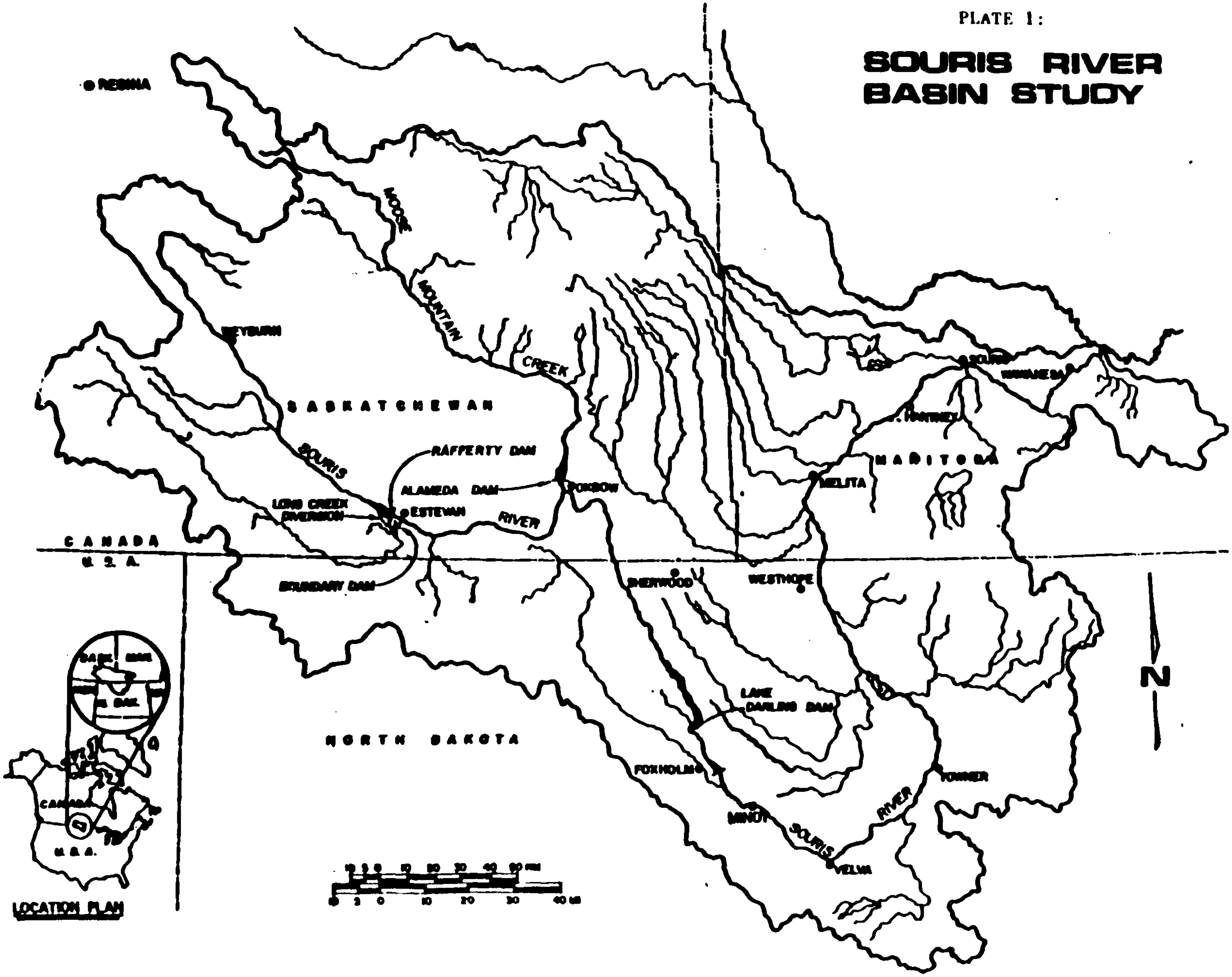

Table 2: Comparison of Features in the Lake Darling and Souris Basin Plans (yes = feature part of plan, no = feature not part of plan)

FEATURE	LAKE DARLING PLAN	SOURIS BASIN PLAN
FLOOD OPERATION PLAN (downstream of Lake Darling)	yes	(1)
LAKE DARLING DAM RAISE	yes	no
Embankment	yes	no
Spillway	yes	no
Outlet Works	yes	(2)
Reservoir Relocation	yes	no
Utility Relocation	yes	no
RENVILLE COUNTY PARK	yes	yes
MCKINNEY CEMETERY	yes	no
ECKERT RANCH	yes	no
REFUGE STRUCTURES:		
Upper Souris Refuge:		
Upgrade Dam 41	yes	no
Raise Service Road	yes	no
Replace Spillway Fishing Area	yes	no
Raise Boat Launches	yes	no
Modify Fences Along Roads	yes	no
Heaters/Actuators at Dam 96	yes	yes
Upgrade Dam 96 Gates	yes	yes
Relocate Boathouse and House	yes	no
Water to Ponds A,B,C, 96 A&B, 87	yes	yes
Levee construction plus dike removal at pool 87	yes	yes
J. Clark Salyer Refuge:		
Carp Barrier	yes	yes
Heaters/Actuators on all Dams	yes	yes
Upgrade and Raise Dam 326	yes	yes
Upgrade and Raise Dam 332	yes	yes
Upgrade and Raise Dam 341	yes	yes
Low Flow Conduit at Dam 320	yes	yes
Pothole Construction	yes	no

Table 2: Comparison of Features in the Lake Darling and Souris Basin Plans (yes = feature part of plan, no = feature not part of plan) (cont.)

FEATURE	LAKE DARLING PLAN	SOURIS BASIN PLAN
DOWNSTREAM URBAN LEVEES:		
Johnson's Addition	yes	yes
Brook's Addition	yes	yes
Talbott's Nursery	yes	yes
Country Club Acres and Robinwood Estate	yes	yes
King's Court and Roslad's Addition	yes	yes
Tierrecita Vallejo	yes	yes
Sawyer	yes	yes
Velva Levees	yes	yes
Minot Channel	yes	yes
RURAL MEASURES		
Floodproofing 106 residences	yes	yes
Purchase of Flowage Easements	yes	yes
GASSMAN COULEE PROTECTION	yes	yes
COMPENSATION TO MANITOBA	yes (3)	yes (3)
FLOOD STORAGE AT RAFFERTY DAM	no	yes
FLOOD STROAGE AT ALAMEDA DAM	no	yes
FLOOD OPERATION IN SASKATCHEWAN	no	yes

(1) Flood operation for the Souris Basin Plan is the same as the Lake Darling plan except that the duration of 500 cfs flows is extended during control of the 50- to 100-year events. For the 75 to 100-year events the release of 5000 cfs is extended to 1 June.

(2) The gated outlet works and appurtenant structures would be redesigned to allow operation for flood control.

(3) Manitoba has indicated that the compensation package for the Lake Darling or Souris Basin plans needs modification. Further discussion and resolution of this issue need to be completed.

other features downstream of Lake Darling common to the Lake Darling plan) are described in the following paragraphs. A comparison of features included in the Lake Darling and Souris Basin plans is given in table 2.

Canadian Storage of Floodwater

3.08 The province of Saskatchewan is currently planning to construct two large multi-purpose dams (Rafferty and Alameda Dams - see plate 1) to provide irrigation water, recreational benefits, and cooling water for the proposed Shand power plant near Estevan, Saskatchewan. The Souris Basin flood control plan calls for increasing the size of the two proposed Canadian dams so that flood water could also be stored in these two reservoirs. In order to get the required flood control, the U.S. would pay up to 41.1 million dollars to the province of Saskatchewan for the construction of larger dams. The U.S. would also agree to allow Saskatchewan to retain a greater portion of the water in the Souris River to offset evaporation losses from the storage of floodwaters in the proposed reservoirs.

Release of Water from Canada

3.09 Under the Boundary Waters Treaty of 1909, an interim agreement in 1959 to govern the apportionment of water between the U.S. and the province of Saskatchewan. This agreement states that the Province of Saskatchewan shall deliver at least 50 percent of the natural runoff as measured at the Sherwood gage to the United States. The Sherwood gage is located on the Souris River .8 mile below the U.S. - Canadian border.

3.10 As part of the project to purchase flood control in the proposed Canadian reservoirs, an agreement between the U.S. and Canada would be instituted to address release of water during flood periods and retention of water during non-flood periods. The major aspects of this agreement are described below.

a) Non-Flood Releases - Under existing conditions, North Dakota is entitled to 50 percent of natural runoff at Sherwood. With the project an "evaporation sharing agreement" would be instituted and would allow the Province of Saskatchewan to deliver only 40 percent of natural runoff to North Dakota under certain conditions. This reduction in North Dakota's share of the water would be used to offset evaporation losses from Rafferty and Alameda reservoirs. The following operating rules would be established to ensure to the extent possible that North Dakota's water supply is protected and to determine when the evaporation sharing would occur:

Saskatchewan will pass 40 percent of natural flows in the Souris River (as measured at Sherwood) with the following exceptions:

- If Lake Darling is less than elevation 1592.0 (msl) on 1 October in any year, then Saskatchewan will pass 50 percent of the natural flows until the level of Lake Darling is above elevation 1593.0 (msl) on 1 October.

- If flow at Sherwood is less than or equal to 15,000 acre feet in any year, then Saskatchewan will pass 50 percent of natural flows in that year.

This evaporation sharing agreement has been fully agreed to by the State of North Dakota and the Province of Saskatchewan, and is consistent with evaporation losses attributable to the flood control portion of the reservoirs in Canada.

b) Releases of Flood Water - Releases from Rafferty and Alameda Dams would be planned to restrict the maximum discharge at Sherwood to 3200 cfs for floods up to and including the 50-year frequency. For floods between the 50- and 100-year frequency, the reservoirs would be operated to restrict the Sherwood maximum discharge to 4000 cfs.

Release of Water from Lake Darling

3.11 Under the Souris Basin Plan, Lake Darling would be used to re-regulate the flood flows from Canada to prevent flooding at Minot and to conform to the 5,000-2,500-500 cfs release plan proposed under the Lake Darling project (see paragraph 3.06). The conservation pool for Lake Darling would also be raised from 1596 to 1597 in order to provide additional water storage capacity for anticipated shortages during dry years.

3.12 Since the Souris Basin plan would control larger floods (i.e. the 25- to 100-year events), it requires extension of the 5,000-2,500-500 cfs release plan for discharges from Lake Darling. For events smaller than the 50-year flood, the release plan would be identical to that of the Lake Darling plan (paragraph 3.06). During events larger than the 50-year flood it would be necessary to prolong the duration of the 500 cfs releases so that all of the stored floodwater is eventually released. For floods in the range of the 75- to 100-year events the 5000 cfs releases would be extended beyond 15 May with a cutback to 500 cfs by 1 June. The discharge of 500 cfs would last until late October for the 50-year event, and until February of the following year for the 100-year event.

3.13 It would also be necessary to have larger preflood springtime drawdowns in order to lower levels in the reservoirs to provide enough volume for storage of the larger floods (i.e. for events larger than the 50-year flood). During control of the 100-year event, preflood drawdown would begin in February and slowly increase until 2500 cfs were being released from Lake Darling in mid March when the flood began. Like the floodwater release plan, the preflood drawdown plan is the same for both the Souris Basin and Lake Darling alternatives for the smaller flood events (i.e. floods smaller than the 50-year event).

Other Features

3.14 The following features were described under the Lake Darling plan and are also included in the Souris Basin Plan:

Feature C: Renville County Park

Feature E: Downstream urban levees

Feature F: Downstream rural measures

Feature G: Downstream flood warning system

Feature H: Refuge structures (table 2 summarizes those refuge structures which are included in the Souris Basin plan)

Feature I: Carp control structure.

SELECTED PLAN

3.15 The Souris Basin plan is the selected plan because the congressional authorization for this study specifically directs the Corps of Engineers to pursue providing flood protection along the Souris River through participation in the construction of multipurpose reservoirs in Saskatchewan (see paragraph 2.03). The Souris Basin plan is preferred over other plans because it provides 100-year flood protection and would not have as many adverse environmental impacts in the U.S. portion of the watershed as other plans which provide 100-year protection. The Lake Darling plan is not preferred because it would not control the larger floods, economic damages associated with larger floods would be excessive, and the adverse environmental effects of the selected plan would not differ much from those of the Lake Darling plan.

3.16 The selected plan would result in environmental damages which are similar to those of the Lake Darling project: reduction in habitat quality due to changes in flow regime during flood years; reduction in waterfowl production on the two National Wildlife Refuges due to disrupted management capabilities during flood years. Various measures to compensate for flood control impacts have been proposed under the Burlington Dam and Lake Darling studies. These measures were used as the basis for developing a habitat compensation package for the proposed Souris Basin plan. The proposed compensation plan is very similar to the plan developed for the Lake Darling Four-Foot Raise project. It focuses on compensation through increasing wetland values and management capabilities on the two National Wildlife Refuges rather than purchasing additional private land (a compromise reached under the Burlington Dam study)

3.17 As part of the mitigation analysis, the potential impacts of the proposed plan and benefits from proposed compensation features were quantified using available information on future hydrologic conditions (appendix 4). Much of the same data used for the Lake Darling analysis was reused in this mitigation analysis. The results of the analysis indicated that net overall losses associated with the proposed plan would be approximately 1330 AAHU[1]. (table 3) and that the benefits provided by the proposed plan (Table 4) would mitigate for approximately 89% of the anticipated quantifiable losses on a basin wide basis. Quantifiable impacts on the Upper Souris River and J. Clark Salyer National Wildlife Refuge would be compensated for by about 123%.

COMPARATIVE IMPACTS OF ALTERNATIVES

3.18 Table 5 presents a comparison of the impacts of the selected plan to those of the Lake Darling plan.

[1] AAHU = Average Annual Habitat Unit. One Habitat Unit (HU) is equal to one acre of optimal habitat. These are averaged over the life of the project to give AAHU (see appendix 4).

Table 3: Impacts (in AAHU) of the Souris Basin Plan

ID	Species Name	AAHU with project	AAHU without project	AAHU change
1	Wetland seg 1 & 2	46.70	64.34	-17.60
2	Wetland seg 3	552.16	565.39	-13.22
3	Wetland seg 4 & 5	332.54	338.14	-5.60
4	Wetland seg 6	8,057.43	8,127.83	-70.39
5	Wetland seg 7	15,192.58	16,080.00	-887.41
6	Woodland seg 1 & 2	0.00	0.00	0.00
7	Woodland seg 3	109.92	111.01	-1.09
8	Woodland seg 4-6	5,444.92	5,481.32	-36.30
9	Woodland seg 7	1,386.23	1,418.00	-31.77
10	Agland seg 1 & 2	0.00	0.00	0.00
11	Agland seg 3	27.08	27.08	0.00
12	Agland seg 4-6	2,420.43	2,595.24	-174.81
13	Agland seg 7	98.24	98.21	0.04
14	Grassland seg 1 & 2	0.00	0.00	0.00
15	Grassland seg 3	10.09	10.38	-0.29
16	Grassland seg 4-6	2,888.25	2,962.77	-74.21
17	Grassland seg 7	1,448.66	1,466.24	-17.58
			TOTAL	-1,330.25

Table 4: Features Proposed to Compensate for the Impacts of the Selected Plan

Feature	Description	Benefits
J. Clark Salyer NWR:		
Raise Dams 326, 332, and 341	Raise dams by 1 foot to maintain vegetation management capabilities	863 AAHU
Lowflow conduit at dam 320	Construct conduit through west end of dam 320 to improve habitat quality at the upper end of pool 326	25 AAHU
Upper Souris NWR:		
Conduit to ponds A,B,C, pool 96, pool 87	Construct a water supply conduit from Lake Darling to pools 96 and 87 to increase managability and habitat values	300 AAHU
	TOTAL	1188 AAHU

Note: Quantifiable losses on the NWR are estimated at 969 AAHU, resulting in 123% compensation of quantifiable refuge losses.

Table 5: Comparative Impacts of Alternatives

Significant Resources	Existing (Base) Conditions	Future Without-Project Conditions	Lake Darling Plan	Souris Basin Plan (Non-flood Years)**	Souris Basin Plan (Flood Years)**
WATER QUALITY/ WATER SUPPLY	Souris River is a class 1A (highest quality) stream. Lake Darling is a class 2C (eutrophic). U.S. receives between 40 and 90 percent of natural runoff of Souris Basin in Canada depending upon the volume of spring flows.	Releases from the Canadian reservoirs and irrigation return flows may degrade water quality in Souris River. Receipt of less water from Canada and lower levels in Lake Darling affect it's ability to supply water during dry years; hence, water shortage and water quality problems in J. Clark Salyer NWR will increase in frequency, especially during extended dry periods.	No effect on the erosion/sedimentation rates above or within Lake Darling. Flood releases from Lake Darling are hydraulically similar to existing conditions; hence, there would be no effect on erosion/sedimentation downstream of the lake.	Evaporation agreement guarantees two-year water supply in Lake Darling. No significant effects on water supply or water quality expected.	No effects on the long term water quality or water supply of the basin are expected. There may be some effect on specific water quality due to additional nutrient release from inundation of new areas by stored flood waters. The flood operation plan would not result in significant hydraulic changes; hence, there would be no effect on erosion/sedimentation rates.
AQUATIC RESOURCES					
Lake Darling	Lake Darling has a good northern pike and walleye fishery. The lake experiences infrequent winterkill.	Winterkill problems in Lake Darling will be worse due to lower water levels and loss of volume to natural sedimentation.	Pre-flood drawdown may cause additional winterkill when compared to future without-project conditions. Higher lake elevations during floods *may enhance spawning.*	No significant adverse effects.	Pre-flood drawdown may cause additional winterkill. Pre-flood drawdown could prevent flooding of spawning areas on an estimated frequency of 6 times per 100 years.
Souris River	Souris River is carp-free in North Dakota and has a diversity of fish species. Low flows in late summer, fall, and winter limit productivity.	Adverse impacts to the Lake Darling fishery may impact fish populations in lower Souris River.	Barrier controls carp invasion. Reduced flood peaks prevent erosion losses of some habitats. Prolonged durations impact other habitats, both beneficially and adverse.	No significant adverse effects expected.	Same as Lake Darling plan.
TERRESTRIAL RESOURCES					
Grassland	Most areas are heavily pastured. Inside refuges native prairie areas are maintained. 8210 acres of grassland have the potential to be affected by floodwater releases.	No significant change from existing conditions.	Grasslands upstream of Verendyre are not flooded as frequently, while downstream grasslands are flooded longer. Grassland lost to raise of flood pool. Loss of 204 AAHU.	The evaporation sharing agreement would cause decreases in minor flooding downstream of Verendyre. This would benefit low-lying agland, but could result in habitat impacts in low-lying wetlands, floodplain forests and grasslands. The impacts would result from encroachment by upland plant species, clearing for agriculture, and increased grazing pressure. Impacts are unquatifiable but expected to be minor.	Losses are somewhat greater than the Lake Darling plan due to prolonged flooding associated with release of floodwater during events larger than the 25-year flood. Loss of 99 AAHU.
Wetlands	Wetlands provide valuable wildlife habitat. They are being drained and filled for agriculture. There are 38,000 acres of wetlands which could be affected by floodwater releases.	Drier conditions induced by the Canadian water supply dams will result in net loss of habitat values within floodplain wetlands in the U.S.	The largest impact of the Lake Darling plan is a result of lower habitat value in wetland areas of the Salyer refuge. Lower habitat values would occur as a result of prolonged flooding of wetlands and loss of management capabilities on the refuge during prolonged releases of stored flood water. Loss of 1100 AAHU.		Wetland losses associated with the Souris Basin plan are somewhat greater than those of the Lake Darling plan due to prolonged flooding associated with release of floodwater during events larger than the 25-year flood. Loss of 794 AAHU.

Floodplain Forests	There are over 10,000 acres of forest which could be affected by the project. Forested areas are important because there is not much forest in North Dakota.	Drier conditions in floodplain forests will result in vegetation changes to drier-adapted species and possibly increased grazing pressure.	Vegetation losses due to prolonged flooding are significant, especially because vegetation will become adapted to drier conditions during non-flood conditions. Most of the losses occur between Verendyre and the upstream end of the Salyer refuge. Loss of 87 AAHU.	(refer to description of impacts to grasslands and wetlands)	Impacts are the same as the Lake Darling plan except the prolonged flooding with the 50 and 100 year events would result in somewhat greater losses in the area between Verendyre and J. Clark Salyer. Loss of 69 AAHU.
Aglands	There are about 8600 acres of agland downstream of Lake Darling which could be affected by the project. Much of this land is rated prime farmland.	Drier conditions may enhance cultivation of the lower protions of the floodplain.	Downstream of Verendyre, aglands in the lower portions of the floodplain would be subject to flooding for longer durations. Other aglands would be flooded less frequently when compared to without-project conditions. Loss of 8 AAHU	(refer to description of impacts to grasslands and wetlands)	As part of the Souris Basin plan agland areas in the 500 cfs floodplain would be flooded for longer durations during control of the 50 and 100 year events. Protection from the 100-year flood at Minot would result in the conversion of 1000 acres of agland around Minot to urban uses. Loss of 175 AAHU.
Wildlife Resources	Wildlife populations are highest on the two National Wildlife Refuges and are lowest in urban areas. Common species include deer, squirrel, rabbit, mink, raccoon, muskrat, and a variety of bird species.	Vegetation changes resulting from drier conditions are expected to favor upland species where there is competition with water-dependent species.	Loss of habitat value in floodplain forests and wetlands would affect wildlife resources. Total quantifiable loss of habitat value estimated at 1393 AAHU.	(refer to description of impacts to grasslands and wetlands)	Wildlife impacts would be basically the same as those of the Lake Darling plan, although some minor additional losses could occur as a result of somewhat greater impacts on vegetation associated with the Souris Basin plan. Total quantifiable loss of habitat value estimated at 1330 AAHU.
Threatened and Endangered Species	The bald eagle, peregrine falcon, and whooping crane may migrate through the project area. The piping plover may also use the area for breeding.	No significant changes from existing conditions.	No adverse effects on these species or their critical habitat.	No adverse effects on these species or their critical habitat.	No adverse effects on these species or their critical habitat.
NATIONAL WILDLIFE REFUGES	The Souris River flows through two refuges: Upper Souris NWR and J. Clark Salyer NWR. Both refuges are very important waterfowl breeding areas.	Lower volumes of water during non-flood years will make management on both refuges more difficult. The effectiveness of Lake Darling for supplying water to the Salyer refuge will be reduced thereby increasing the potential for avian disease problems.	Water level fluctuations in Lake Darling would degrade habitat values on 1779 acres of wetland, 659 acres of woodland, 1064 acres of grassland, and 445 acres of agland. The flood release plan would affect operating capabilities on the Salyer refuge which results in degraded value of 20100 acres of wetland.	The potential for water shortages and avian disease problems would increase over without project conditions during drier non-flood years. The probabilities for problems or their magnitude cannot be determined. The evaporation agreement is designed to reduce potential impact as much as possible.	Impacts on the Upper Souris refuge would be significantly lower than the Lake Darling plan because the lake would not be raised four feet. Only 215 acres of wetland would be affected by the Souris Basin plan on the Upper Souris refuge. Prolonged release of floodwater during the 50 and 100 year events would affect refuge operation and waterfowl production.

CANADIAN NATURAL RESOURCES	Two regions could be affected: a) Souris Basin in Saskatchewan; b) Souris Basin in Manitoba. Primary areas of concern include the land around proposed dams in Saskatchewan and floodplain resources in Manitoba.	Construction of dams in Canada will flood large areas (54 miles of riverine habitat) of valuable wildlife habitat in Saskatchewan. Evaporation losses from the reservoirs will make it difficult to maintain their water levels. Water supplied to Manitoba will be less due to additional retention in Saskatchewan.	Flood durations will be prolonged in some floodplain areas in Manitoba which will result in some degradation of habitat values.	Water levels in the Canadian reservoirs would be easier to maintain with the evaporation agreement. Some minor increases in water shortage problems in Manitoba may also occur as discussed above.	Storage of floodwater in Canada would flood habitat around the reservoirs but would not affect any resources of global significance. Impacts in Manitoba would be the same as the Lake Darling plan except that habitat losses would be somewhat greater due to the prolonged flooding during control of the 50 and 100 year events.
RECREATIONAL RESOURCES	The two National Wildlife Refuges are major waterfowl hunting areas. Lake Darling is heavily used for fishing. Both refuges also have hiking, canoeing, and picnicing facilities.	Water-based recreation will be hampered by drier conditions. Winter fish kills in Lake Darling will become more common.	Storage of floodwater to elevation 1605 would flood some recreational facilities around the lake. Damages at Souris Valley Golf Course would be reduced.	No significant changes from future without conditions.	No significant changes from future without conditions.
AESTHETIC VALUES VISUAL RESOURCES	Diversity of topographic features and habitat types in the Souris River valley provide unique visual aspects within the northern great plains landscape.	No significant changes from existing conditions.	Mud flats would form at the upstream end of Lake Darling after storage of floodwater. No other effects on visual resources.	No significant changes from future without conditions.	No significant changes from future without conditions except that damages at Souris Valley Golf Course would be reduced.
SOCIAL RESOURCES Transportation	Federal-aid bridges form vital links in the region's network of roads, serving Minot, Minot Air Force Base, and the rural areas.	Roads and bridges will continue to be maintained by Federal, state, and local funds. Minot Air Force Base will continue to intensively used (and financially contribute to the upkeep of) much of the road system in the region.	Highway 5 bridge would be unusable due to floods for up to 146 days (for heavy military vehicles) and up to 22 days (passenger vehicles); Grano, Green (Hwy 28), and the Soo railroad crossings are also affected. Movement of farm products, other commercial activities, school children, and normal social activities would all be subject to major detours.	No significant changes from future without conditions.	No significant changes from future without conditions.
National Defense	Minot Air Force Base is a Strategic Air Command facility controlling many nuclear missiles. Located on all sides of the Souris River in remote rural areas, the sites require constant accessibility for maintenance, reprogramming, and protection against sabotage.	No significant change from present conditions.	Ability to maintain and protect nuclear missile sites would be severely curtailed for up to 146 days due to flooding. Staff would be streached very thin, with greatly lengthened work days to accomplish routine and emergency missions. It may be necessary to radically restructure operating arrangements.	No significant changes from future without conditions.	No significant changes from future without conditions.

Social Cohesion	There is a history of conflict related to Corps' Burlington flood control project, private land owner ship issues, and locus of project impacts. Flood control plans offering less than 100-year protection are seen as temporary solutions. City sales tax was passed in support of the Souris Basin Plan.	No predictable change, but probably less confidence in the ability of the Federal or local government to solve flooding problems.	Some conflicts related to private ownership, locus of impacts, and local costs and tax consequences.	Some conflicts related to water supply during regional drought conditions.	Some conflicts related to private ownership, locus of impacts, local costs and tax consequences.
CULTURAL RESOURCES	Although surveys are not yet complete, the following significant cultural resources have been identified: a) one property on the National Register of Historic Places (NRHP); b) 11 sites determined elegible for the NRHP.	No significant changes from existing conditions, although some sites may not be flooded as frequently.	Raise of the Lake Darling floodpool to elevation 1605 would inundate sites around the lake.	No significant changes from future without conditions.	No significant changes from future without conditions.

** The terms "non-flood years" and "flood years" are defined in Section 5. Although flood years only occur in approximately 5 percent of all years, the impacts associated with flood operation are severe and therefore constitute the majority of the impacts of the Souris Basin alternative.

4.00 AFFECTED ENVIRONMENT

4.01 This section describes the environment and resources which would be affected by the two flood control alternatives. The first part of this section (Existing Envirionmental Conditions) gives an overview of the Souris River Basin and identifies the significant resources associated with the project. The section concludes with a description of future conditions without implementation of any flood control project (Future Environmental Conditions Without Flood Control). This last portion is especially important because these conditions are compared to future with-project conditions in section 5.00 to document the environmental effects of the proposed action.

EXISTING ENVIRONMENTAL CONDITIONS

4.01 The Souris River headwaters are in the Canadian Province of Saskatchewan. The river crosses the international border near Sherwood, North Dakota, and makes a 358-mile loop through Renville, Ward, McHenry, and Bottineau Counties before entering the Province of Manitoba near Westhope (Plate 1). The Souris River basin is an area of approximately 24,800 square miles, of which 15,480 are in Canada and 9,320 are in the United States (almost entirely in North Dakota).

4.02 The existing conditions in the Souris River Valley upstream of Verendrye are those of a small stream in an oversized valley. The valley floor averages three-quarters of a mile wide and lies 100 to 200 feet below the ground-moraine plain. The valley walls are fairly steep-sided. Downstream of Verendyre, the river valley is in the flat glacial Lake Souris area, and is one-half to 3 miles wide.

4.03 Two U.S. Fish and Wildlife Service (FWS) National Wildlife Refuges (NWR), the Upper Souris NWR and the J. Clark Salyer NWR, impound extensive reaches of the upper and lower Souris loops, respectively. The FWS-owned Lake Darling Dam in the Upper Souris National Wildlife Refuge is the largest impoundment. Its purpose is to supply water to downstream impoundments in both refuges, however it has also been operated to provide some flood storage during spring runoff. The two refuges are nationally known for their waterfowl production. The diversity of habitat in the refuges and along the entire length of the Souris River also supports numerous other wildlife species.

4.04 Agriculture is the primary business in the Souris basin, and there are many small farming communities in the area. Minot is located near the midpoint of the Souris loop and is the region's major center for commerce, manufacturing, and services.

4.05 Land use trends, including floodplain development and wetland drainage, may be contributing to the floodplain problems in the area. For smaller, more frequent events, wetland drainage reduces flood storage capacity in the basin and increases runoff into the river and its tributaries.

4.06 The Souris River floodplain forest comprises about 2 percent of North Dakota's forests. This constitutes a significant resource in a State that ranks 50th in the country in total forest acreage.

4.07 Population in the Souris basin is unevenly distributed among the seven counties:

	1980 Population
Bottineau County	9,338
Burke County	3,822
McHenry County	7,858
(includes city of Velva, 1,101)	
Mountrail County	7,679
Pierce County	6,166
Renville County	3,608
Ward County	58,392
(includes city of Minot, 32,843)	

4.08 During the 1970's, this North Dakota study area declined in population by 3.5%, but the city of Minot actually grew slightly, and has a fairly stable and diversified economic base. Flooding is a significant problem for Minot, both in terms of intermittant crises, and as an ongoing restriction of development in the floodplain.

SIGNIFICANT RESOURCES

Water Quality

4.09 Souris River - Souris River flows are variable, with flood flows generally occuring in April or early May. Low flows generally occur from late summer through fall and winter. Periods of no flow lasting from days to weeks at a time are not uncommon during low flow periods. The Souris River can be characterized as having high levels of dissolved solids (400-1300 mg/l), sulfates (100-500 mg/l), and chloride (20-225 mg/l) with the higher levels occuring during low flow periods. The North Dakota State Health Department has observed that streamwater quality following runoff events will usually have the following characteristics as compared to low-flow conditions: (1) increased coliform counts (2) lower total dissolved solids, and (3) generally no corresponding drop in phosphates comparable to that of the total dissolved solids.

4.10 Non-point source pollution, particularly from agricultural sources, is a major factor in the water quality of streams in the Souris Basin. The North Dakota State Health Department has noted that non-point source pollution has slowed the improvement of surface water quality despite the rapid waste treatment advances that have been made by municipalities, industries, and other point source dischargers.

4.11 The Minot sewage treatment plant is currently the most significant point source on the Souris River. Discharges from municipal sewage lagoons have caused occasional acute water quality problems in recent years, including fish kills. This generally occurs during low flow periods when the discharge causes dissolved oxygen depletion.

4.12 The State of North Dakota has classified the Souris River as a 1A stream. The quality of water in this class is suitable for the propagation of resident fish species and for boating, swimming, and other water recreation. Treatment for municipal use may require softening, and the treated water must meet

bacteriological, physical, and chemical requirements of the State Health Department. The quality of class 1A water also permits its use for irrigation, stock watering, and wildlife without injurious effects.

4.13 Of particular importance with the proposed project is the quality of Souris River water as it enters the United States. Appendix 9 contains North Dakota water quality standards for the Souris River and an analysis of ambient water quality in the Souris River above the border prepared as part of the Saskatchewan EIS studies. Two parameters are worth special note. Dissolved oxygen levels frequently fall below the North Dakota standard of 5.0 mg/l during the winter. Boron levels on occasion exceed the State standard of 0.75 mg/l. It should be noted that boron is relatively non-toxic to aquatic life and the standards are set to protect more sensitive plant life, should the water be used for irrigation.

4.14 Lake Darling - North Dakota has classified Lake Darling as a 2C cool water fishery, capable of supporting growth and propagation of non-salmonid fishes and associated aquatic life. The C-class characteristic (present degree of eutrophication) applies to a lake that is presently somewhat degraded and is progressing toward further degradation. The reservoir is shallow and is expected to have a consistent pattern of weak and intermittent thermal stratification for the months of May thru August.

4.15 Lake Darling is nutrient rich and currently experiences intense algal blooms during the summer. These blooms are composed almost entirely of the blue-green alga Aphanizomenon flos-aque. Die-offs accompaying algal blooms exert high demand on dissolved oxygen and can cause the deeper areas of the lake to become anoxic.

4.16 Low dissolved oxygen conditions have been a problem in the past in Lake Darling, especially during winters that have a combination of factors that induce "winterkill" conditions such as low water levels, heavy snow cover, cloudy ice, and long periods of ice cover. Documented winterkills have occured in February-March in 1960, 1967, and 1978. Undoubtedly localized anoxic conditions probably occur most winters but go undetected.

Water Supply

4.17 "Natural flow" on the Souris River at Sherwood is equally divided between the United States and Canada under a 1959 agreement (paragraph 3.09). Since establishment of the agreement, the U.S. has received between 40 and 125 percent of the natural flow depending on the volume of spring discharges. This has occurred because the province of Saskatchewan has lacked the capability to store their legal share of the runoff during high flows. Greater than 100% natural flow can occur because drainage projects in Canada result in greater runoff than would occur naturally.

4.18 Primary water rights along the U.S. protion of the Souris River (63,000 acre-feet per year) belong to the two FWS refuges. Rights to a smaller amount of water are held by the city of Minot and a few private individuals. The earliest water rights belong to the Eaton Irrigation District near Verendyre, North Dakota. An international agreement also requires the U.S. to deliver a minimum of 20 cfs in the Souris River to Manitoba, Canada from June to October except during drought conditions.

Aquatic Resources

4.19 The 358-mile Souris River loop in the United States provides habitat for twenty-eight fish species representing eight families. Aquatic habitat occurs in three distinct types - lake, riverine, and marsh. Lake Darling provides the bulk of the lake habitat and the Souris River the riverine. The majority of the marsh habitat is found in J. Clark Salyer Refuge, the upper reaches of Lake Darling, and along the stretch of river below Lake Darling dam to Baker Bridge.

4.20 Fish species found in the Souris River and Lake Darling are characteristic of those found in warm to cool rivers in the Upper Midwest. Northern pike (Esox lucius), walleye (Stizostedion vitreum vitreum), and yellow perch (Perca flavescens) are very common and are the principal sportfish. White sucker (Catostomus commersoni), black and brown bullhead (Ictalurus melas and I. nebulosus), and fathead minnow (Pimephales promelas) are the most common forage species.

4.21 Lake Darling - The Lake Darling fishery has been managed by the Fish and Wildlife Service. Northern pike and yellow perch reproduce naturally in the lake and the walleye fishery is supported by stocking. Angler use was estimated at 27,348 fisherman-days in 1974-75. In the winter of 1979-80 ice fisherman use for a three-month period was estimated at 1,138 fisherman-days. A creel survey during the summer of 1983 estimated use for May thru September at 11,335 fisherman-days with an estimated a harvest of over 6,000 pounds of northern pike and over 1350 pounds of walleye.

4.22 A limiting factor in the management of Lake Darling (beside the lack of walleye spawning habitat) is the problem of occasional winterkill. Winterkill in Lake Darling is caused by a combination of factors that include winter lake levels, ice clarity, snow cover, length of ice cover, nutrient levels, and aquatic plant growth. Management personnel at the Upper Souris National Wildlife Refuge have indicated that if water levels in Lake Darling are above elevation 1593 winterkill conditions will generally not develop. They have observed that when water levels are below 1592 the lake becomes susceptable to winterkill subject to the other factors mentioned above.

4.23 During the period 1942-85 Lake Darling entered the winter below 1592 about 23 per cent of the time (10 out of 44 years). Years of documented winterkill do not correlate with years of low water reinforcing the belief that low water levels alone do not cause winterkill, they only make the lake more susceptable to winterkill.

4.24 Souris River - The Souris River supports the same type of fishery in terms of species as Lake Darling. However, it probably does not receive the same fishing pressure. Unfortunately there are no studies documenting fisherman use of the riverine portion of the study area.

4.25 Spawning habitat for walleye in the riverine areas is limited to areas below low-head dams and isolated gravel-rubble-riprap deposits. J. Clark Salyer National Wildlife Refuge has extremely good nothern pike spawning conditions, but winterkill in these shallow impoundments severely limits fish management. Other reaches of the Souris River suffer occasional winterkill because of low flows and impaired water quality. Lake Darling is considered a

primary source of fish for repopulating the riverine portions of the Souris River.

4.26 The potential for project-induced migration of carp (Cyprinus carpio) into the United States portion of the Souris River was a significant issue for both the Burlington Dam and the Lake Darling projects. It is believed that carp are confined at present to that portion of the Souris River downstream of the Wawanesa Dam, Manitoba. The concern was that the Lake Darling project would allow carp to pass over the Wawanesa Dam and facilitate upstream migration. If carp were to migrate upstream of Wawanesa, they could establish themselves in the pools of the J. Clark Salyer NWR where considerable habitat is available. The habitat destruction that carp can cause is well known.

4.27 Since there are no physical or physiological barriers upstream, once carp are established in the refuge, they could range freely through the U.S. portion of the Souris and Des Lacs Rivers, eventually reaching the headwaters in Saskatchewan.

4.28 An analysis was made during the Lake Darling project studies to determine the existing condition, the circumstances under which carp would be able to reach the U.S., and the effect of the Lake Darling project itself. A discussion of the analyses may be found in appendix 1 to the Lake Darling Final EIS. Copies can be obtained upon request from the St. Paul District.

Terrestrial and Wetland Resources

4.29 The terrestrial and wetland resources in the Souris Basin are described in seven sections: grasslands, wetlands, floodplain forests, agricultural lands, wildlife resources, National Wildlife Refuges, and threatened or endangered species. The acreges of the different habitat types summarized by geographic location are given in table 6.

4.30 Grasslands - Untilled grasslands provide important habitat for prairie wildlife species. However, due to agricultural development, little pristine native prairie grassland acreage remains in the Souris Valley. Vegetative species that currently exist in this community include bluestem grasses (Andropogon spp.), sages (Artemisia spp.), switchgrass (Panicam virgatum), grama grasses (Bouteloua spp.), dropseed grasses (Sporobolus spp.), needlegrasses (Stipa spp.), astors (Astor spp.), wild roses (Rosa spp.), goldenrods (Solidago spp.), wild rye grasses (Elymus spp.), and slender wheatgrass (Agropyron trachycaulum). Wildlife species which use grassland habitat in the Souris Valley include white-tailed deer (Odocoileus virginianus), red fox (Vulpes fulva), white-tailed jackrabbit (Lepus townsendii), badger (Taxidea taxus), sharp-tailed grouse (Pedioecetes phasianellus), blue-winged teal (Anas discors), willet (Catoptrophous semipalmatus), and western meadowlark (Strunella neglecta).

4.31 Untilled grassland in the floodplain and on valley slopes is usually heavily pastured. Inside refuge boundaries, grassland is maintained for wildlife, with some farming and cattle grazing permitted when compatible with refuge management. Private and Federal holdings of grasslands total about 15 percent of the land area in the Souris floodplain and roughly 20 percent in the United States portion of the basin (Lunan et al., 1973).

Table 6

Baseline Conditions-Terrestrial and Wetland Resources

Habitat	Segment(1)	Habitat Acres (2)	Habitat Unit Value (HUV)
Wetland	1-2	215	.43
	3	1,346	.43
	4-5	805	.43
	6	15,926	.53
	7	20,100	.80
Woodland	1-2	0	.71
	3	157	.71
	4-6	7,731	.71
	7	2,115	.71
Agricultural land	1-2	0	.35
	3	82	.35
	4-6	8,100	.35
	7	350	.35
Grassland	1-2	0	.54
	3	20	.54
	4-6	5,708	.54
	7	2,482	.66

(1)Segment 1 - Saskatchewan border to upper end of Lake Darling, Segment 2 - upper end of Lake Darling to Lake Darling Dam, Segment 3 - Lake Darling Dam to Baker Bridge, Segment 4 - Baker Bridge to Burlington Dam, Segment 5 - Burlington Dam to Logan, Segment 6 - Logan to J. Clark Salyer NWR, Segment 7 - J. Clark Salyer NWR.

(2)Segments 1 and 2: up to elevation 1597 in the raised Lake Darling conservation pool. Segments 3-7: within the 5,000 ft^3/s flooded outline downstream of the Lake Darling dam.

There are approximately 8200 acres of grassland downstream of Lake darling which might be affected by flood control alternatives.

4.32 Wetlands - Wetland areas along the Souris River have a variety of functions and provide a wide range of values. Potential functions of wetlands include detention of floodwater, recharge of groundwater resources, removal of sediment and contaminants from river water, protection of shoreline from erosion, and provision of recreational and scenic values. The most notable feature of the Souris River wetlands is the waterfowl habitat they provide. Wetlands are used extensively as breeding habitat, feeding and resting areas during migration, and for cover during molting, brood rearing, and other post-breeding activities.

4.33 About 200 acres of wetlands occur in the backwater areas of Lake Darling between elevations 1596 and 1597. Downstream of the lake there are approximately 38,200 acres of wetland which might be affected by the flood control alternatives, the majority of which are found on the Salyer refuge. Common plant species in wetland areas along the Souris River include cattails (Typha spp.), bulrushes (Scirpus spp.), sedges (Carex spp.), spikerushes (Eleocharis spp.), reed canary grass (Phalaris arundinacea), common reed grass (Phragmites communis), sago pondweed (Potamogeton pectinatus), smartweeds (Polygonum spp.), arrowgrasses (Triglochin spp.), and burreeds (Sparganium spp.).

4.34 About 300,000 acres of wetlands in the Souris basin in North Dakota are considered important to waterfowl. The type and quality of the individual wetlands varies considerably. Easements are held by resource agencies on more than 200,000 acres, and about 43,000 acres are managed exclusively or primarily for fish and wildlife use (Water Resources Management Plan, 1981, Souris-Red-Rainy Region, Upper Mississippi River Basin Commission). The Souris-Red-Rainy Region Basin Commission has estimated that less than half of the original wetland acreage in the basin remains. As the remaining wetlands continue to be drained, waterfowl habitat and other wildlife habitat are reduced. Wetlands owned and managed for wildlife purposes will become increasingly important as the focus of available waterfowl habitat in the basin.

4.35 Wetlands are a very valuable resource and yet are being rapidly lost to agricultural and urban development. For this reason careful consideration was given to potential impacts on wetlands, and reasonable measures to avoid and mitigate wetland losses were given high priority.

4.36 Floodplain Forest - Floodplain forest is the smallest ecological community in the Souris loop, but is very important because this type of vegetation is scarce in North Dakota. The forests in the Souris River between the North Dakota-Saskatchewan border and the upstream boundary of the J. Clark Salyer National Wildlife Refuge represent about 2 percent of the State's total forests. About 10,700 acres of floodplain forest occur in the floodplain between Lake Darling and the Manitoba border. Approximately 816 acres of this total are in the Upper Souris Refuge, 7,731 acres are between the Upper Souris and Salyer Refuges, and 2,115 acres are within the Salyer Refuge.

4.37 Predominant plant species found in the floodplain forest include elm (Ulmus americana), green ash (Fraxinus pennsylvania), box elder (Acer

negundo), bur oak (Quercus macrocarpa), willow (Salix spp.), cottonwood (Populus deltoides), hawthorn (Crataegus rotundifolia, chokecherry (Prunus virginiana), dogwood (Cornus stolonifera), wolfberry (Symphoricarpos occidentalis), and wild rose (Rosa spp.). Wildlife species using floodplain forest include white tailed deer, raccoon (Procyon lotor), beaver (Castor canadensis), mink (Mustela vison), pheasant (Phasianus colchicus), wood duck (Aix sponsa), great blue heron (Ardea herodias) and black-capped chickadee (Parus atricapillus).

4.38 Agricultural Lands - Agricultural land in the Souris River floodplain is used primarily for small grain farming (wheat), alfalfa farming, and grazing. Wildlife species that use agricultural lands include white-tailed deer, white-tailed jackrabbit, red fox, striped skunk (Mephitis mephitis), gray partridge (Perdix perdix), mallard (Anas platyrhynchos), Franklin's gull (Larus pipixcan), and horned lark (Eremophila alpestris). Most agricultural use occurs on formerly native grasslands because the soil types are conducive to dry-land agriculture.

4.39 There are about 8,580 acres of agricultural land downstream of Lake Darling that could be affected by flood control alternatives. Of all acres within the 5000 cfs floodplain there are about 6,860 acres of prime farmland soil types in Ward County and about 6,810 acres in Bottineau County. The McHenry County detailed soil survey was scheduled for completion in 1986, but a generalized prime farmlands map provided by the Soil Conservation Service (SCS) indicates that most of the area adjacent to the Souris River contains less than 10 percent prime farmland soil types. The prime farmland classification does not distinguish between those lands currently in agricultural production and those that are in other uses, but have the potential to be prime farmland.

4.40 Wildlife Resources - Numerous wildlife species are dependent upon habitat provided in the Souris River floodplain. Wildlife populations are highest on the two National Wildlife Refuges (NWR) where there is an abundance of good habitat and limited disturbance, and lowest in urban areas where lack of habitat and frequent human disturbance results in less desirable conditions. The predominant big game species in the Souris River Valley is the white-tailed deer which relies upon the floodplain forest areas to provide winter cover and food. Numerous furbearers and other mammals including squirrel, rabbit, mink, raccoon, and muskrat also depend upon habitat adjacent to the river for critical life requisites. Many bird species use the river and adjacent wetland areas for habitat during summer months. In addition, these areas are important feeding and resting areas during spring and fall migrations.

4.41 National Wildlife Refuges - The two Souris River national wildlife refuges (NWR) contain the most valuable wildlife habitat along the river and are important environmental concerns related to the proposed project. Both of these refuges serve as important, dependable waterfowl habitat reserves during drought years. The primary purposes of the Upper Souris River NWR are production of huntable waterfowl, provision of other necessities in the life cycles of waterfowl, and water supply to J. Clark Salyer NWR (through assured released from Lake Darling). The Upper Souris refuge (containing 32,000 acres) also provides habitat for upland big game, furbearer, and nongame species; winter cover for deer from the surrounding area; public use of

refuge-related resources, including some haying and grazing; and prevention of waterfowl depredations on private lands. There is also a significant amount of big game (deer) hunting on the refuge. Lake Darling is used extensively for walleye and northern pike fishing.

4.42 J. Clark Salyer NWR contains about 58,700 acres in Bottineau County adjacent to and including about 75 miles of the Souris River. Five low-head dams form large pools that provide important waterfowl habitat. The primary purpose for the Salyer refuge is waterfowl production, and it is considered to be one of the most productive refuges in the nation. Deer, upland game, furbearers, and nongame species are also found on the refuge, as well as a good northern pike fishery. J. Clark Salyer NWR is also an important stop-off point for migrating waterfowl and other birds that breed in Canada in the summer.

4.43 Threatened and Endangered Species - According to the U.S. Fish and Wildlife Service, four federally-listed endangered species might be present in the project area: the peregrine falcon (Falco peregrinus), the bald eagle (Haliaeetus leucocephalus), the whooping crane (Grus americana), and the piping plover (Charadrius melodus). The peregrine falcon is a seasonal migrant, during the fall and spring, in the project area. Many bald eagles migrate through the project area during the fall and spring, particularly through the J. Clark Salyer Refuge. The project area contains no critical habitat for either the eagle or the falcon.

4.44 During recent years, a number of sightings of whooping cranes have been confirmed for the project area during spring and fall migration periods. The cranes migrate between their wintering grounds around the Aransas National Wildlife Refuge in Texas and their summer nesting grounds at Wood Buffalo National Park, the Northwest Territories, Canada. The Souris Basin is on the eastern third of the cranes' primary migration route. They generally use sandbars in slow moving rivers, and other areas with shallow surface water and little emergent vegetation, to feed roost and loaf during migration (see exhibit 1, Lake Darling Draft Supplement on Endangered Species Biological Assessment of the Burlington Dam Flood Control Project).

4.45 The Souris River basin, including Lake Darling, was used by nesting piping plovers between 1950 and 1972. Although suitable nesting habitat may still exist in the basin, recent surveys by biologists from the U.S. Fish and Wildlife Service and the North Dakota Natural Heritage Program failed to document any breeding by piping plovers. A lone piping plover was seen at Lake Darling in July of 1982, but this bird showed no indication of breeding activity and was probably a migratory visitor.

4.46 Canadian Natural Resources - There are two regions in Canada which could be affected by the various alternative flood control plans: (1) Souris basin in Saskatchewan from the proposed Canadian reservoirs to the U.S. border; (2) the Souris River Valley in Manitoba downstream of the U.S. border. The Souris River Valley in Saskatchewan is very similar to the valley in the upstream reaches of the U.S. portion of the basin. Most of the floodplain is agricultural land and there are some wetlands in topographic depression and areas where the valley is wider. Channel capacity is relatively large and is bordered by natural levees which are vegetated with a narrow row of trees.

4.47 The Souris River in Manitoba flows through areas which are more similar to the downstream reaches of the U.S. protions of the valley (i.e. downstream of Verendyre). The river valley is wider and has more wetlands. Much of the land adjacent to the river is cultivated and is subject to inundation when flows on the river exceed 600 cfs.

Recreational Resources

4.48 National Wildlife Refuge-Operated Recreation Sites - Public use of resources on the Upper Souris and J. Clark Salyer National Wildlife Refuges ranges from traditional water-related activities (such as fishing, boating, swimming, and picnicking) to big game hunting. Recreational water use at the Upper Souris National Wildlife Refuge comprises 96 to 98 percent of total annual refuge use (table 7). Estimated annual visitation has varied over the last 10 years from a high of 121,502 in 1973 to a low of 32,741 in 1978. Spring flooding accounts for some of this fluctuation because it affects early season (May/June) fishing activity, which accounts for 20 to 40 percent of annual refuge use. Recreation facilities at J. Clark Salyer National Wildlife Refuge include a 22-mile auto scenic trail; a 13-mile canoe trail complete with interpretive brochure; photography and bird-watching activities along trails and from observation towers; upland game; big game, and waterfowl hunting; fishing; and picnicking.

Table 7
Upper Souris National Wildlife Refuge
Public Use Visitation, 1972-1982

Year	Recreational Use(1)	Total Public Use
1972	22,324	46,092
1973	120,342	121,502
1974	71,558	73,281
1975	54,647	55,802
1976	37,356	38,140
1977	57,813	59,947
1978	31,540	32,741
1979	48,885	50,590
1980	88,237	89,813
1981	82,762	85,665
1982(2)	50,811	53,152

(1) Recreation activities include picnicking, swimming, boating, and fishing.
(2) Annual use only through September.

4.49 Refuge Fishing Activity - During the summer of 1983, a creel survey was conducted by the U.S. Fish and Wildlife Service on Lake Darling. Some of the key findings reflecting current refuge use include the following:

1. Forty-four percent of observed fishing pressure between April 30 to September 5, 1983, occurred at the dam, 44 percent at Grano Crossing, and 12 percent at Greene Crossing.

2. Twenty-one percent of fisherman interviewed were from the Minot Air Force Base.

3. Sixty-nine percent of all fishing was from shoreline. Shoreline fishermen caught about 65 percent of all fish recorded. The average number of people per fishing party was 2.2, and the average length of fisherman day was 3.o hours.

4. Average number of fish caught per hour of effort was .088, and an estimated total fishing pressure of 11,335 person-days. Sixty-six percent of harvest was northern pike, followed by smaller percentages of walleyes, yellow perch, and smallmouth bass.

4.50 Natural Landmark Program - The Upper Souris Refuge has been identified by the U.S. Department of the Interior (in its ecological theme analysis of the Great Plains Natural Region) as having outstanding natural features potentially suitable for a natural landmark designation. These features include stable communities of deciduous lowland forests and native grasses plus seasonal concentrations of native animals, especially waterfowl.

4.51 Appendix 5 contains a listing of other recreational sites in the project area.

Aesthetic Values/Visual Resources

4.52 J. Clark Salyer NWR and the Souris River Valley between Burlington and the Saskatchewan border including the Upper Souris Refuge are regionally unique areas of high aesthetic value. A diversity of habitat types and topographic characteristics found in the river valley provide unique visual aspects within the northern greatplains landscape. The visual aspects of the refuge's woodland acreage is an important component because of North Dakota's scarce forest resources.

Cultural Resources

4.53 Archeological and Historic Surveys - Numerous archeological and historic surveys of the Souris Basin within the United States have been conducted over the past decade. Nearly all of these efforts have been conducted in conjunction with studies or projects of the St. Paul District. In 1974 a small survey was done in the vicinity of Minot, North Dakota as part of a channel modification project for flood control and also areas associated with the Burlington Dam. In 1977 the University of North Dakota conducted a preliminary field reconnaissance and literature search of the Burlington Dam project area. Later that year, a large scale archeological and historic survey was also conducted by the University of North Dakota. The historic survey was conducted in an area from the Canadian border south to the Des Lacs-Souris confluence. The archeological survey was conducted in the same area but was much less intensive upstream of Lake Darling. In the Fall of the next year, the University of North Dakota completed a small survey of a road detour associated with the Burlington Dam project. Between 1982 and 1984 intensive survey was undertaken along the Souris River. This survey was conducted by Powers Elevation in conjunction with the Lake Darling project. The survey included all lands below elevation 1610 above Lake Darling and the downstream levees at Burlington to Minot, Sawyer, and Velva. St. Paul District is

presently initiating a contract for archeological survey work upstream of the northernmost area previously surveyed. This survey, scheduled to be completed in the Spring of 1988, will include those areas within the 4,000 cfs flow. Impacts to resources found during this survey will be discussed in the NEPA document associated with the Feature Design Memorandum for Rural Protection. Based upon the data collected to date, it is anticipated that archeological resources will be recorded with the same frequency and distribution as was found in the intensively surveyed downstream areas.

4.54 Archeological Testing - Testing of the archeological sites that were located during the survey efforts began in 1978 when the University of North Dakota tested three sites between Lake Darling and the proposed Burlington Dam. Only one of these sites, the Washek Site (32WD407) was considered to be eligible for the National Register of Historic places. This site was located at the proposed Burlington Dam, and it would not be impacted as a result of this project.

4.55 During the 1983 and 1984 field seasons, Powers Elevation tested 21 archeological and historic sites associated with the Lake Darling flood control project. These sites were originally recorded by both Powers Elevation and the University of North Dakota. Most of these sites were located either at Lake Darling or between Lake Darling and the Canadian border. One of the sites was located at Velva, North Dakota. Of these 21 sites, 17 are prehistoric and 4 are historic archeological sites. The five prehistoric sites that were determined eligible for the National Register of Historic Places are described in appendix 6.

4.56 In addition to the 21 sites tested by Powers, 11 other sites were scheduled to be tested but testing was never completed. Ten prehistoric sites (32RV401 through 32RV410) that were originally recorded by the University of North Dakota were not able to be relocated. It was discovered that the water levels of Lake Darling were extremely low during the 1977 field season, and normal water elevations were recorded during the 1983 testing season. As a result, these sites were eliminated from the testing contract. One additional archeological site (32WD24) was not tested because permission to complete the testing was denied by the landowner.

4.57 Canadian Surveys - Archeological and historic surveys have been conducted along the Souris River in Saskatchewan, Canada in conjunction with the Shand Thermal Generating Station. Survey efforts began in 1984 with an intensive survey of the Shand plant site and a reconnaissance survey of high probability areas within the Rafferty reservoir upstream of Estevan, Saskatchewan. Additional survey within the Rafferty reservoir was undertaken in 1986 along with a brief examination of Alameda reservoir. Further survey work and assessment of the significance of the located sites is planned prior to the construction of the Canadian reservoirs. It is predicted that over 400 sites may be located within the Rafferty and Alameda project areas.

4.58 Significant Resources - In compliance with Section 106 and Section 402 of the National Historic Preservation Act, as amended, the National Register of Historic Places and the World Heritage List have been consulted. As of 4 December 1986 there are no properties on the World Heritage List that would be affected by the proposed Souris Basin project. One property listed on the

National Register of Historic Places and 11 properties determined eligible for the National Register are described in appendix 6.

Social Resources

4.59 Flooding - Minot, with a great deal of its development in the Souris floodplain, on both sides of the river, is highly vulnerable to flooding. Numerous flood have been fought since the city was established; property losses have always been high, property values have suffered, and lives have been lost. An early participant in the Federal flood insurance program, Minot has lobbied strongly for exemptions from some of the requirements which are felt to be overly restrictive. In the rural areas both upstream and downstream of the city, residents are less constrained by flood insurance regulations, and express more of an "I can live with it" attitude about flooding.

4.60 Housing, Employment, and Education - Housing availability in North Dakota Planning Region 2 (consisting of Bottineau, Burke, McHenry, Mountrail, Pierce, Renville, and Ward Counties) is the same as for the State (10 percent vacant as of 1980). However, this varies greatly by counties within the region, from a low vacancy rate of 7 percent in Ward County (1,489 vacant units) to a high of 18 percent (317 units) in Burke County.

4.61 The annual average labor force has been reduced by 7 percent (1979 to 1983) for Region 2, at the same time that unemployment has increased from 4.4 percent to 6.2 percent. The change in the labor force was significant because of the declining population of Minot Air Force Base.

4.62 Declines in the Planning Region 2 school enrollments during the 1970's have ranged from a 13 percent loss in Bottineau County to a 37 percent loss in McHenry County. Ward County, with a 20 percent decline, is representative of the State as a whole. These declines have left significant underutilized physical school capacity. To finance their schools, the districts in Region 2 levied 101.16 average mills, slightly over the State average of 97.40 (1981-1982). Some school districts in the valley serve both sides of the Souris River, making access across the river an important consideration for students, teachers, and Special Education programs.

4.63 Transportation - Although total use of river crossings is low by comparison with an urban area, much of the traffic which moves in the region uses a crossing for an average trip. Those crossings most important to the social, commercial, and national security aspects of the region are: State Highway 5 (Federal Aid - Primary route designation), with an average daily traffic volume of 440 vehicles, including the heaviest vehicles usesd by Minot Air Force Base; Lake Darling Dam or County 6, which also carries the heaviest defense vehicles, except in icy winter conditions, and has an average volume of 300; Grano Crossing (Federal Aid - Secondary), serving an average of 250 vehicles; and State Highway 28 or Greene Crossing (Federal Aid - Secondary), averaging 120 vehicle crossings daily. The network of roads is maintained by funds from local, state, and federal highway departments, as well as contributions from the Military Traffic Management Command to ensure the quality necessary for defense missions. North Dakota requires all primary and secondary crossings to be capable of passing the fifty-year flood. The Soo Line Railroad crossing is an important branch line, and serves as an

alternate to the main line through Minot during floods, averaging 160 cars per week, for grain, fertilizer, fuel, and farm machinery.

4.64 National Defense - Minot Air Force Base is a Strategic Air Command facility controlling many nuclear missiles, as part of the United States' global military network. Located on all sides of the Souris River in remote rural areas, the sites require constant accessibility for maintenance, reprogramming, and protection against sabotage.

4.65 Social Cohesion - There are four components of social cohesion related to these alternatives: **private ownership of property; locus of project impacts; project costs and taxation**; and **water supply**.

4.66 The issue of **private versus public ownership of land** is a sensitive one, particularly in areas where there are considerable public holdings, recent acquisitions, or holdings for unpopular purposes, such as wildlife mitigation. The study area is sensitive on all counts. The Corps proposal for a Burlington Dam was stopped partially by opposition to further Federal land acquisition. These concerns were fundamental to the political compromise that allowed the proposed raise of Lake Darling, and provide impetus for siting the reservoirs on Canadian land.

4.67 Another source of previous conflict has been the **locus of project impacts**. There is consensus that Renville County has little, if anything, to gain from any of the proposed Corps actions. In the opinion of Renville County Park users and property owners (surveyed in 1983), the proposed developments are entirely for the benefit of downstream residents, particularly the city of Minot. Downstream, particularly in the Towner area, current flood release patterns have been accommodated by irrigation and agricultural practices.

4.68 The **local costs** of either alternative are very high, in comparison with local ability to pay. Financial capacity is governed by the **tax bases** and legal limitations of different taxing authorities. The State Water Commission's legal limitations would require a specific legislative appropriation before it could provide substantial assistance on the project. One appropriation of $905,000 was made available by recent legislation, an appropriation of one million dollars is currently being sought. The city of Minot voted in a 1 percent sales tax to support flood control, but additional sources of funds will be necessary. Special assessments, property taxes, and easement donations are being considered.

4.69 There is a strong perception in Minot that a **limited municipal and industrial water supply** acts to constrain economic development in the city. Souris River water is the preferred source, but the city must rely heavily on its aquifer, with higher processing costs, due to the undependable flow which can be taken from the Souris. There is an international "interim agreement" which controls the share of water the United States will receive, and the share which must be in turn released to Manitoba. Water rights of the US Fish and Wildlife Service and other users, such as Eaton Irrigation District, further limit the river's availability for municipal purposes.

FUTURE ENVIRONMENTAL CONDITIONS WITHOUT FLOOD CONTROL

ASSUMPTIONS

4.70 The following factors are assumed to affect the environmental resources of the Souris River Basin in the future in the absence of flood control:

(1) Agricultural Development - Some natural areas will be cleared or drained for conversion to cropland. Natural areas which are not directly affected will be indirectly affected by intensification of cropping practices (increased sedimentation, use of fertilizers and pesticides) on surrounding agricultural land.

(2) Urban Development - Although floodplain development will continue to be restricted under current floodplain regulation, the trend toward movement of rural residents into urban areas is expected to continue and will result in some minor development of floodplain land.

(3) Canadian Dams - Rafferty and Alameda Dams will be constructed for water supply in Saskatchewan but would not provide flood control benefits.

4.71 The third assumption has the biggest effect on future conditions because the Canadian dams will have a major effect on the quantity, and possibly quality, of water in the Souris River reaching the United States. This assumption is based on historical trends in Saskatchewan's water resource development, the current shortage of a firm water supply at Boundary Dam, and recent discussions with Saskatchewan representatives.

GENERAL DESCRIPTION

4.72 The problem of inadequate water supplies is prevalent in the Souris River Basin in Saskatchewan. As within the U.S. portion of the basin stream flows are intermittent and subject to periods of low or no flow. Since the 1930's, Saskatchewan has progressively developed their water supply capabilities through the construction of six reservoirs with a total storage capacity of 75,400 acre-feet. The latest effort was in 1983 when the capacity of Weyburn Reservoir was increased.

4.73 In 1978, the Souris River Basin Study Board recommended increasing the capacity of Weyburn Reservoir, development of the Estevan Valley Aquifer, and, with a major industrial demand, the construction of Rafferty Reservoir. As noted above, the capacity of Weyburn Reservoir has been increased. In 1984 Saskatchewan Power Corporation began planning the construction of Rafferty and Alameda Reservoirs. Saskatchewan's need to expand their electrical power base is a major factor in their current water resource development planning.

4.74 During the period August 1984 to the present, many meetings have been held with Saskatchewan representatives concerning their interest in proceeding with the construction of Rafferty and Alameda reservoirs for water supply only. Saskatchewan representatives have indicated on several occasions during these meetings that they are prepared to proceed with the construction of Rafferty and Alameda reservoirs for water supply if the U.S. is unable to meet their construction and cost sharing schedule. U.S. representatives have also been told that Saskatchewan has already made financial commitments with Japan

to construct two water cooled turbines in Saskatchewan. In addition they have procured the necessary funds to proceed with the project.

4.75 Construction of Rafferty and Alameda dams for water supply will result in the province of Saskatchewan exercising its right to retain 50% of the Souris River water as specified in the 1959 interim agreement. Under existing conditions, Canada retains between 0 and 54 percent of natural runoff (approximately 15% of the water on average - see table 8); hence, water supply will probably take on added significance once the Canadian dams are finished. Specific impacts associated with lack of water include a reduction in habitat management capabilities on the National Wildlife Refuges, difficulty in maintaining water levels in Lake Darling, declines in the Lake Darling fishery and waterfowl production, and the potential for lack of water at Minot for urban uses and sewage dilution.

4.76 Construction of the Canadian dams for water supply may also affect flooding in the U.S. portion of the basin. A hydrologic analysis of the Canadian dams indicates that evaporation losses may result in the availability of a significant amount of storage for flood water in the reservoirs; hence, ancillary flood control benefits may result if a major flood occurs after an extended period when evaporation losses exceeded runoff replacement.

4.77 Although there is potential for ancillary flood control benefits from construction of the Canadian reservoirs, future without-project conditions assume that existing flooding conditions will persist in future years. This assumption maintains consistency with the hydrologic assumptions used to analyze project effects.

SIGNIFICANT RESOURCES

Water Quality

4.78 The future water quality of the Souris River and Lake Darling will depend upon man's activities. Conditions within the United States portion of the Souris Basin relative to sources of water quality degradation are not expected to change significantly. The cool, dry climate and lack of abundant surface water will likely dictate against any massive conversion to more intensive agriculture. Conditions may even improve to some degree with improved water treatment technologies and increasing public recognition of non-point source pollution as a significant water quality problem.

4.79 The natural process of sedimentation in Lake Darling will aggravate dissolved oxygen depletion and other water quality problems as the volume of the reservoir decreases and the lake becomes shallower. Estimates based on the sedimentation rate in Lake Darling are that over the next 100 years sedimentation will reduce the volume of Lake Darling at full pool (1596.0) by about 20 per cent.

4.80 The largest impact to water quality in the Souris River over the next 100 years may be water resource development in Saskatchewan. The development of the capability to retain 50% of the natural flow of the Souris River will increase the frequency of low flow conditions in the United States portion of the basin from what has been experienced historically. Low flow conditions are

Table 8: Annual Volume at the North Dakota-Saskatchewan Border after Institution of the 1959 Agreement

Year	Recorded at Sherwood	Natural Flow at Sherwood	Recorded as % of Natural	50% of Natural Flow
1959	17,158	24.677	69.5	12,338
1960	90,104	126,263	71.4	63,131
1961	3,976	7,750	51.3	3,875
1962	10,007	18,218	54.9	9,109
1963	19,330	41,529	46.5	20,764
1964	38,260	49,780	76.9	24,890
1965	81,160	88,269	91.9	44,134
1966	56,770	63,434	89.5	31,717
1967	36,030	44,378	81.2	22,189
1968	12,150	22,700	53.5	11,350
1969	300,600	280,259	107.3	140,130
1970	188,292	180,313	104.4	90,157
1971	101,900	88,744	114.8	44,372
1972	160,349	169,928	94.4	84,964
1973	10,290	12,547	82.0	6,274
1974	308,000	287,095	107.3	143,548
1975	388,800	315,408	123.3	157,704
1976	629,123	526,482	119.5	263,241
1977	10,752	12,955	83.0	6,478
1978	102,442	131,805	77.7	65,902
1979	377,039	333,753	112.9	166,877
1980	19,930	27,885	71.5	13,943
1981	12,060	18,070	66.7	9,035
1982	172,500	175,840	98.1	87,920
1983	144,700	129,400	111.8	64,700
1984	9,629	14,822	65.0	7,411
1985	37,884	55,488	68.3	27,744
Average	123,657	120,289	85.0	60,144
Median	56,770	63,434		31,717
Lower 1/4	12,150	22,700		11,350

the times when water quality problems become most accute and have the most impact on water users.

4.81 Aside from the reduction in the amount of water reaching he U.S., the proposed Rafferty and Alameda reservoirs, in and of themselves, have the potential for having substantial impact upon water quality in North Dakota. Water quality concerns associated with construction of the dams for water supply that have been identified by St. Paul District, following consultation with the North Dakota Department of Health, center around the following:

a. Thermal stratification and bottom discharge

b. Nutrients

c. Dissolved solids

d. Irrigation

4.82 Some modelling has been conducted by Saskatchewan to determine if Rafferty reservoir would thermally stratify. The potential exists for both Rafferty and Alameda resevoirs to stratify, based upon their proposed depth and physical characteristics. Saskatchewan is currently proposing bottom discharge for both reservoirs, though recent information indicates that they are considering a multi-level outlet for at least Alameda reservoir. Bottom discharges from thermally stratified reservoirs can result in the discharge of anoxic waters that have elevated levels of dissolved metals, phosphorus, and unionized ammonia. To quantify the quality of water that will be discharged from these reservoirs would require further analysis of the potential for Rafferty and Alameda to stratify and an analysis of the probable "zone of withdrawal" around the proposed discharge structures.

4.83 If oxygen depleted water is discharged from the Saskatchewan reservoirs during low flow conditions, both winter and summer, it is unknown whether the Souris River would be able to reoxygenate itself before it reached the U.S. border. Reoxygenation would remove the above mentioned constituents from a dissolved state. A number of complex factors would effect the rate of reoxygenation such as water temperature, BOD and COD load, rate of discharge, and length of open river for reoxygenation to name a few. Further studies entailing the use of a river model would be required to quantify the effects of thermal stratification and bottom discharge on the quality of Souris River water entering the U.S.

4.84 When the Canadian reservoirs are initially flooded there is going to be a significant release of nutrients from decomposition of flooded organic matter in the soils and flooded vegetation. This is a phenomenon common to new reservoirs and generally lasts in the range of 5 to 10 years. The magnitude of this effect has not been analyzed, and thus it is not possible to predict what the impact will be on waters entering the U.S., other than that there likely will be an increase in nutrient levels in the Souris River from this effect. The nutrient of primary concern would be nitrogen as this is the limiting nutrient in the Souris River (pers. communication North Dakota Public Health Department).

4.85 Another water quality concern with reservoirs in a semi-arid environment is that high evaporation rates in conjunction with low inflows tend to result in an increase in concentration of dissolved minerals. Saskatchewan has done some modelling in this area, using a Water Quality for River and Reservoir Systems model. The results indicate no appreciable impact to downstream areas (Souris Basin Development Authority EIS).

4.86 The Souris Basin Development Authority EIS projects that approximately 12,000 acres of land is suitable for irrigation in the areas of Rafferty and Alameda reservoirs, primarily in the valleys downstream of the resrvoirs. No projections of water quality impacts from irrigation development were made in the EIS. Irrigation development is expected to evolve over the first twenty years following reservoir construction. It is not possible to predict what the water quality effects may be as information is not available on what types of irrigation equipment would be used, whether there would be any return water, specific irrigation rates, and other information that would be necessary to quantify potential impacts.

4.87 In summary, the construction of Rafferty and Alameda reservoirs for water supply has the potential for substantial impact upon the quality of Souris River water entering the U.S. However, without further studies it is not possible to make any quantitative predictions of future-without water quality conditions. Saskatchewan and North Dakota are holding discussions concerning the impact of these reservoirs during non-flood periods that may result in additional studies being conducted.

Water Supply

4.88 Less water will be delivered to the U.S. in the future as Saskatchewan developes the ability to capture 50 percent of the natural runoff in the Souris River. It is anticipated that the water supplied will be sufficient to meet water rights along the river, although there may be some problems during periods of drought. There will be no regulated release of water during floods to provide protection in the United States.

4.89 In the future there may also be water shortages that do not affect legal water rights, but affect other uses of Souris River water (e.g. small irrigation projects). The frequency and duration of these kinds of shortages can be expected to increase in the future.

Aquatic Resources

4.90 Lake Darling - The value of Lake Darling as a fishery resource is expected to naturally decline over the next 100 years. This is based upon the expectation that winterkill will become a more significant problem as time passes. Winter water levels below 1592 make the lake more susceptable to winterkill. Historically, Lake Darling has had winter water levels below this elevation 23 per cent of the time. Sedimentation will reduce the volume of water in the lake. By the year 2036 a lake elevation of 1593 will be required to provide the same lake volume that an elevation of 1592 does now. By year 2086 the required comparable elevation will be 1594. Thus the effect of sedimentation over the next 100 years will be to increase the susceptablility of Lake Darling to winterkill. Based strictly on historic data the lake would,

over the next 100 years, enter winter with water levels below an elevation comparable to present day 1592 approximately 45 per cent of the time.

4.91 A compounding factor will be the Canadian development of the capability to retain 50 per cent of the natural runoff. Using historic flow data from 1912-1974, a hydrologic simulation model projecting Canadian retention of 50 per cent of natural runoff indicates that Lake Darling will enter winter with water levels below 1592 approximately 63 per cent of the time. Adjusting for projected sedimentation volume loss increases this percentage to about 72 percent.

4.92 As can be seen from the discussion above, the combination of sedimentation and Canadian water resource development is probably going to have a significant effect on the ability of Lake Darling to sustain a viable sport fishery due to increased susceptability to winterkill. Future management options available to offset this effect appear limited at this time. Raising the level of Lake Darling to increase it's volume would be costly, have other adverse environmental effects, and there may not be enough water available when Canada retains 50 per cent of the runoff. Mechanical aeration would be an option for the Fish and Wildlife Service, though likely costly in a reservoir of this size.

4.93 Souris River - If Lake Darling is important to the natural restocking of the Souris River as currently postulated, a future decline in the lake fishery may in turn result in a decline in the river fishery. In addition the Canadian retention of their share of the water will increase the occurrence of low flow conditions. This would be expected to adversely effect the quality of the habitat and the fishery in the Souris River.

4.94 Without the implementation of flood control it is expected that the Souris River above the Wawanesa Dam would continue to remain carp-free. The increased retention and use of water by Saskatchewan interests could even add further control by increasing the occurrence of low winter flows and associated winterkill downstream of J. Clark Salyer Refuge.

Terrestrial Resources

4.95 Grassland - Future reductions in the volume of water received from Saskatchewan should not have any marked effect on grassland areas. Grassland areas are not highly dependent upon water supplied by the Souris River because they are generally located at higher elevations. It is possible that drier conditions may make some grassland areas in the lower portions of the floodplain (especially in downstream areas) more conducive to farming or urban development. Losses of this type will most likely be minor because large floods occuring under future without-project conditions will tend to discourage agricultural or urban development in the floodplain.

4.96 Wetlands - Reduced flows in the floodplain are expected to affect wetlands in the study area. The primary effects would occur during dry or average runoff years when retention of water in Saskatchewan will reduce the inundation of wetlands in the downstream portion of the watershed. The degree of impact on downstream floodplain wetlands is expected to be varried; some wetlands which have a lot of open water without much interspersion of emergent vegetation may be benefitted by drier conditions; other wetlands may

experience changes in vegetation which would lower their habitat value (e.g., a formerly diverse marsh may become dominated by cattails under drier conditions); some wetlands may become so dry that they are converted to cropland and lose much of their habitat value. In general, it is felt that drier conditions induced by Canadian water supply dams will result in a net loss of habitat value within floodplain wetlands in the U.S.

4.97 Floodplain Forests - Like wetlands, floodplain forest areas in the downstream portion of the Souris River will also be drier due to reductions in the water volume received from Saskatchewan. Understory vegetation is expected to become more dense in undistrubed areas as vegetation adapted to drier conditions (xerophytes) begins to become established. Over several decades species composition within the floodplain forests is expected to become more xerophytic.

4.98 Floodplain forest areas may also be subject to increased grazing pressure with reductions in the volume of water received from Saskatchewan. Floodplain forest areas are used to provide cover and feeding for cattle during the winter. Presence of drier conditions may enhance this kind of use.

4.99 Agricultural Lands - Although the continued presence of floods will probably minimize additional clearing of land for agriculture, drier conditions may enhance cultivation of the lower portions of floodplain areas (especially in the area downstream of Verendyre).

4.100 Wildlife Resources - The vegetation changes described above can be expected to affect wildlife populations, with drier conditions having the most severe effects on water-dependent wildlife. Wetland losses and changes in the floodplain forest will result in some decrease in waterfowl production and in some loss of habitat value for non-breeding waterfowl, especially in J. Clark Salyer NWR (see below). Overall the drier conditions are not expected to result in substantial changes in wildlife populations; however, these conditions will tend to favor upland species (grouse, pheasant, etc.) in situations where there is competition with water-dependent species (mallard, geese, shorebirds, etc.).

4.101 National Wildlife Refuges - The most dramatic difference between present and future without-project conditions as defined by the future assumptions (paragraph 4.72) occurs in the operation and management of the two National Wildlife Refuges (NWR). As explained above (paragraph 4.87), there will be increased potential for winter fishkills in the lake. Less water will also make it more difficult to meet the needs for sewage dilution at Minot and manage the water needs at the J. Clark Salyer NWR during dry years.

4.102 Long-duration dry periods can disrupt the 5-year management cycle used at J. Clark Salyer NWR. During dry years cattail control programs are set back which ultimately affects the waterfowl habitat value of refuge marshes and causes decreased waterfowl production. Disease problems (primarily avian botulism) and associated waterfowl losses are also more prevalent during dry years. The potential for these problems to occur is expected to increase under future without-project conditions.

4.103 Threatened and Endangered Species - Populations of the threatened and endangered species are assumed to remain constant under future without-project

conditions. Since these species are primarily migratory in this area of North Dakota and since there is an abundance of migratory habitat in the area, it is doubtful that any of the future assumptions would affect these species.

Canadian Natural Resources

4.104 Rafferty and Alameda dams will be constructed in Canada and operated for irrigation and water supply for the Shand power plant. This construction would result in a multitude of adverse impacts in Canada including inundation of natural riverine habitat, flooding of wildlife habitat, loss of wintering habitat for deer, reduced deer and upland gamebird populations loss of good quality waterfowl production habitat, and elimination of upstream fish movement and spawning areas. There are also effects on Canadian social resources, cultural resources, water supply, water quality, and recreational facilities. These impacts and others are being analyzed in an environmental impact statement under preparation by the Souris Basin Development Authority, Estevan, Canada.

4.105 Construction of the reservoirs will also affect water supply in the U.S. portion of the basin (paragraph 4.85) which, in turn, affects water supply in Manitoba. Impacts in Manitoba are expected to parallel those in the U.S. portion of the basin (refer to the impacts described in preceeding paragraphs). The existing minimum flow agreement between the U.S. and Manitoba will continue to assure that flows into Manitoba will not drop below 20 cfs.

Cultural Resources

4.106 This section discusses the without project condition of significant archeological and historic sites found along the Souris River above Lake Darling and along the shoreline of Lake Darling. Changes from existing conditions occur as a result of changes in flood frequency, flood duration, and in potential for erosion.

4.107 Flood Frequency - The overall frequency of flooding with the Canadian dams in place but with no flood storage provided is minimally decreased over existing conditions. Initial runoff collected within the basin between Lake Darling and the Canadian dams is not affected by the upstream dams and the impacts to cultural resources will therefore remain the same as existing conditions. For small flood events, runoff from the basin above the Canadian dams may be reduced by these dams. In this case, the frequency of flooding at downstream archeological and historic sites will be reduced. Larger flood events will not be affected by the Canadian dams and the impact to downstream cultural resources will remain approximately the same as existing conditions.

4.108 At six sites (32RV23, 32RV101, 32RV420-422, and 32RV431), the frequency of flooding will not be be changed over existing conditions. These sites are only affected by flows greater than those impacted by the Canadian dams for small scale flood events.

4.109 Flood Duration - For flood events that will affect significant sites above Lake Darling and along the shoreline of Lake Darling, there will be no change in the duration of flooding.

4.110 Potential For Erosion - Erosion potential at significant resources will not be greatly changed over the existing conditions. The greatest potential for erosion is during larger flood events with a greater duration. Since these events will not be affected by the Canadian dams, impacts will not be changed from existing conditions.

Recreation Resources

4.111 Under the future without condition, water-based recreation will be adversely affected. Receipt of less water from Saskatchewan will increase the potential for winter fish kills thereby lowering the success rate for fishing and reducing the amount of fishing occuring and/or the quality of the experience. Lower lake levels will adversely affect boating due to decreased surface area (crowding) and possibly reduced access. Degradation of the river due to less dilution of pollutants will also affect water-based recreation.

4.112 Drier conditions in the valley will also result in a shift in the ratio of upland/wetland habitat toward more upland. This shift may affect hunting patterns if it results in a relative increase of upland game species. Given existing data it is difficult to determine the potential for a shift in hunting patterns or its effect on recreation-based businesses.

4.113 Overall, a net decrease in recreational resources and/or experiences is expected under the future without condition.

Aesthetic Values / Visual Resources

4.114 The primary factor affecting visual and aesthetic values is the amount of fluctuation in water levels within Lake Darling. Frequent, large water level fluctuations result in large areas without any vegetation which are then scarred by erosion. Under future without project conditions, the amount of water level fluctuation may increase somewhat, however it is not likely to have an appreciable effect on the valley's visual appeal.

Social Resources

4.115 Transportation - Roads and bridges will continue to be maintained by Federal, state, and local funds. Minot Air Force Base will continue to intensively use, and financially contribute to the upkeep of, much of the road system in the region.

4.116 National Defense - No significant changes are predicted.

4.117 Social Cohesion - No significant changes are predicted, although local interests would be extremely frustrated if neither the Souris Basin nor Lake Darling 4-foot raise alternatives were implemented. Although the data may be incomplete, water supply conditions will possibly be worse when the Canadians are able to successfully capture their full legal share of the river's flows.

5.0 ENVIRONMENTAL EFFECTS

5.01 The purpose of this section is to describe the environmental impacts of the Souris Basin and the Lake Darling alternatives for providing flood protection in the Souris River Basin. Impacts are described in two sections:

1) Environmental Impacts - Non-Flood Years: A description of impacts associated with the evaporation sharing agreement (paragraph 3.11).

2) Environmental Impacts - Flood Years: A description of the impacts associated with storage and controlled release of water during floods.

5.02 Some of the environmental impacts of the Souris Basin and Lake Darling flood control alternatives can not be quantified. This is due primarily to the unpredictability of future without conditions and a lack of technical capability to evaluate some of the complex hydrologic and environmental changes expected to occur. The most significant factors are elaborated upon below:

a. Under future without conditions Saskatchewan will be developing the capability to retain 50% of the Souris River basin runoff that is allowed under international agreement. While it is expected that they will retain the bulk of their water from spring runoff there are no controls requiring them to take the full 50% or restricting when they may retain their water. This makes it extremely difficult, if not impossible to accurately predict future hydrologic conditions in terms of how much water may reach the U.S. in any given year, especially to the level of detail necessary to quantify environmental impacts.

b. The Souris Basin is very complex to analyze hydrologically, especially with the addition of a number of reservoirs. To analyze hydrologic changes to the detail that is required to quantify environmental impacts is currently at the limits, and possibly beyond hydrologic modelling capabilities.

c. Predicting the quantitative impact to floodplain habitats of changing water regimes is difficult at best, even when a fixed operating plan is available. Not having a fixed operating plan for non-flood conditions makes it impossible.

5.03 While it is not possible to quantify changing future without conditions or impacts as they related to changing water supply, some quantification is possible in assessing flood operation impacts because flood operation involves a relatively fixed operating plan. A detailed analysis was conducted during the Lake Darling project studies and has been expanded upon for the Souris Basin alternative. Additional hydrologic modelling and analysis, while expensive, would allow for a more accurate quantification of flood operation impacts. This additional modelling and analysis would take approximately two years. The Province of Saskatchewan is unwilling to accept a two year delay for a U.S. commitment, therefore the impact analysis relies heavily on available hydrologic data and the analysis conducted during the Lake Darling studies and on information provided in the Canadian EIS.

5.04 Another area where quantification of impacts is currently not possible is water quality. This is not due to a lack of technical capabilities but rathern the unique nature of this project. Rafferty and Alameda reservoirs are being constructed in Saskatchewan, and they have the potential for having a substantial effect on the future without water quality of the Souris River. Saskatchewan has done limited water quality modelling of these reservoirs which does not permit a good quantitative evaluation of potential water quality effects. Without this basic modelling of these reservoirs it is not possible tc quantitatively predict what the water quality impact of adding flood storage and the release of stored flood waters will be.

5.05 The impact analysis is based on a comparison of flood and non-flood periods using the assumed future conditions (paragraph 4.70). All of the impacts described in the following pages stem directly or indirectly from this comparison which is summarized in table 9. The following definitions are used in the table and throughtout the remainder of the impact discussion:

a) Low Runoff Periods - Those periods when the evaporation sharing agreement dictates a 50-50 split of Souris River water (conditions are dry enough that the level of Lake Darling is below elevation 1592 on October 1). This condition would occur approximately 65 percent of the time.

b) Moderate Runoff Periods - Those periods when the evaporation sharing agreement dictates a 60-40 split of Souris River water, but there is no operation for flood control. This condition would occur approximately 30 percent of the time.

c) Non-Flood Years - Those years when the reservoirs would not be used to provide flood control (this includes both low and moderate volume years). This condition would occur in approximately 95 percent of all years.

d) Flood Years - Those years when reservoirs would be used to provide flood control. This would occur in approximately 5 percent of all years.

ENVIRONMENTAL EFFECTS-NON FLOOD YEARS

5.06 The following paragraphs describe the hydrologic changes and environmental impacts in non-flood years. The Lake Darling alternative would have no effect during non-flood years; hence, the discussion focuses on the effects of the Souris Basin alternative. The only portion of the Souris Basin project which would have any effect during non-flood years is the evaporation sharing agreement (paragraph 3.10). The following impacts would be a direct result of this agreement.

HYDROLOGIC CHANGES

5.07 To determine the hydrologic changes which would result from the evaporation sharing agreement, a water budget model developed by the Saskatchewan Power Corporation for the Souris River Basin was run using two different scenarios: (1) Saskatchewan retains 50% of natural flows; (2) Saskatchewan retains 60% of natural flows. Input data are the historic mean monthly runoff volumes from 1912 through 1974. The model also assumes that Rafferty, Alameda, and Lake Darling reservoirs are all full at the outset.

5.08 Under the assumptions of paragraph 4.70, Canada will retain 50 percent of natural flows; hence, future without-project conditions are represented by the first run of the hydrologic model (50 percent split of natural flows). Future with-project conditions for the Souris Basin alternative are approximated by switching between the first and second runs according to the criteria in the evaporation sharing agreement. This approximation assumes that historic runoff records are representative of future conditions, and that the evaporation sharing agreement can be adequately modeled by switching between the 50 percent and 60 percent runs of the hydrologic model. The results of the analysis include estimates of the with and without-project runoff volumes at a variety of points along the river (tables 10 and 11) and the with and without-project water surface elevations in Lake Darling (table 12).

5.09 The hydrologic analysis indicates that the 60-40 split of runoff volume would occur approximately 35% of the time. A summary of results from table 10 shows that the with and without-project conditions would differ in 264 of the 756-month period of record (approximately 35%). This translates into 3,454,698 acre feet of water delivered under without-project conditions over the 63-year period of record versus 3,367,157 acre feet delivered under with-project conditions (a 2.5% reduction).

5.10 Differences between with and without project conditions occur in years when 60 percent of the natural flow in the Souris River would be retained in Saskatchewan, but volume is low enough that flood operation is not required. These "moderate flow years" are typified by little or no flow from late summer through winter, and larger spring flows which generally remain within the river channel. It is assumed that the extra 10% of natural flows resulting from the evaporation sharing agreement would be retained in Saskatchewan during spring flows when water is relatively plentiful.

IMPACTS TO SIGNIFICANT RESOURCES - NON-FLOOD YEARS

5.11 Primary effects of the Souris Basin alternative on significant resources during non-flood years would occur as a result of lowered springtime flows during moderate runoff years. Upstream of Verendyre, moderate springtime flows are contained in the channel under without-project conditions; hence, lowering flows would only affect in-channel resources (Lake Darling, water supply, etc.). Downstream of Verendyre, channel capacities are low and out-of-channel resources (wetlands, floodplain forests, etc.) are inundated during springtime flows without the project. Lowered springtime flows would result in drier conditions for many of the significant resources in downstream areas thereby causing changes in the vegetation composition and habitat value of these resources.

5.12 Specific impacts of the Souris Basin alternative on affected significant resources are described in the following paragraphs.

Water Quality and Water Supply

5.13 When analyzing potential low flow impacts, water supply and water quality go hand-in-hand, as generally, low flows in the Souris River aggravate water quality problems. The impacts of the Souris Basin project on water supply and water quality are tied to the proposed evaporation sharing

Table [illegible] Summaries of the hydrologic condition of significant resources during spring flows

LOW VOLUME YEARS

RESOURCE	EXISTING CONDITIONS	FUTURE WITHOUT (50/50 split)	SOURIS BASIN PLAN FUTURE WITH (50/50 split)	LAKE DARLING PLAN FUTURE WITH (50/50 split)
Lake Darling	water levels low	water levels very low	same as future without condition	same as future without condition
U. Souris Refuge	management difficult due to low water	management problems worse than existing	same as future without condition	same as future without condition
J.C. Salyer Refuge	management difficult, low water, disease problems	lower water, disease problems	same as future without condition	same as future without condition
Water Quality	potential problems in L. Dar. and Salyer	water quality problems more frequent	same as future without condition	same as future without condition
Water Supply	potential problems at Salyer & Manitoba	water supply problems worse	same as future without condition	same as future without condition
Wetlands (upstream)	no spring flooding	no spring flooding	same as future without condition	same as future without condition
Agland (upstream)	no spring flooding	no spring flooding	same as future without condition	same as future without condition
F. Forest (upstream)	no spring flooding	no spring flooding	same as future without condition	same as future without condition
Grassland (upstream)	no spring flooding	no spring flooding	same as future without condition	same as future without condition
Wetlands (downstr)	those in 500 cfs channel are flooded in spring	no spring flooding	same as future without condition	same as future without condition
Aglands (downstr)	those in 500 cfs channel are flooded in spring	no spring flooding	same as future without condition	same as future without condition
F. Forests (downstr)	those in 500 cfs channel are flooded in spring	no spring flooding	same as future without condition	same as future without condition
Grasslands (downstr)	those in 500 cfs channel are flooded in spring	no spring flooding	same as future without condition	same as future without condition

MODERATE VOLUME YEARS

RESOURCE	EXISTING CONDITIONS	FUTURE WITHOUT (50/50 split)	SOURIS BASIN PLAN FUTURE WITH (60/40 split)	LAKE DARLING PLAN FUTURE WITH (50/50 split)
Lake Darling	water levels maintained	water levels generally lower	water levels lower than future without	same as future without condition
U. Souris Refuge	good operating capabilities	operation of L. Darling is hampered	operation is further hampered	same as future without condition
J.C. Salyer Refuge	good operating capabilities	generally less water, some disease problems	less water, more disease problems	same as future without condition
Water Quality	water quality is adequate	some water quality problems during late summer	water quality problems worse than without cond.	same as future without condition
Water Supply	water supply is adequate	potential problems at Salyer and Manitoba	water supply problems worse than without cond.	same as future without condition
Wetlands (upstream)	rarely flooded in spring	no spring flooding	same as future without condition	same as future without condition
Agland (upstream)	rarely flooded in spring	no spring flooding	same as future without condition	same as future without condition
F. Forest (upstream)	rarely flooded in spring	no spring flooding	same as future without condition	same as future without condition
Grassland (upstream)	rarely flooded in spring	no spring flooding	same as future without condition	same as future without condition
Wetlands (downstr)	most are flooded in spring	low wetlands are flooded in spring	only lowest wetlands are flooded in spring	same as future without condition
Aglands (downstr)	many are flooded in spring	lowest areas are flooded in spring	generally not flooded	same as future without condition
F. Forests (downstr)	most are flooded in spring	low areas are flooded in spring	only lowest areas are flooded in spring	same as future without condition
Grasslands (downstr)	many are flooded in spring	lowest areas are flooded in spring	generally not flooded	same as future without condition

YEARS WITH FLOOD OPERATION

RESOURCE	EXISTING CONDITIONS (flood operation at L. Dar.)	FUTURE WITHOUT (flood operation at L. Dar.)	SOURIS BASIN PLAN FUTURE WITH (flood operation at L. D. and Can.)	LAKE DARLING PLAN FUTURE WITH (flood operation at L. D.)
Lake Darling	lake full, spring drawdown for floods	lake full, spring drawdown for floods	lake full, spring drawdown of longer duration	lake full flood storage to elev. 1604
U. Souris Refuge	good operating capabilities	good operating capabilities	same as future wihtout conditions	problems with stored floodwater at higher elevation
J.C. Salyer Refuge	some operational problems with too much water	some operational problems with too much water	frequent problems with too much water	intermediate problems with too much water
Water Quality	water quality is adequate	water quality is adequate	same as future wihtout conditions	same as future wihtout conditions
Water Supply	water supply is adequate	water supply is adequate	same as future wihtout conditions	same as future wihtout conditions
Wetlands (upstream)	flooded during springtime floods	flooded during springtime floods	215 acres of wetland flooded for long durations	extensive flooding of wetlands upstream of L.D.
Agland (upstream)	flooded during springtime floods	flooded during springtime floods	high land not flooded, low land flooded longer	flooding of agland upstream of L.D.
F. Forest (upstream)	flooded during springtime floods	flooded during springtime floods	mostly flooded during springtime floods	flooding of floodplain forests upstream of L.D.
Grassland (upstream)	flooded during springtime floods	flooded during springtime floods	mostly flooded during springtime floods	flooding of grasslands upstream and around L.D.
Wetlands (downstr)	flooded during springtime floods	flooded during springtime floods	flooding duration increased, sometimes dramatically	flooding duration increased
Aglands (downstr)	flooded during springtime floods	flooded during springtime floods	flooding durations increased in lower areas	flooding durations increased in lower areas
F. Forests (downstr)	flooded during springtime floods	flooded during springtime floods	flooding duration increased, sometimes dramatically	flooding duration increased
Grasslands (downstr)	flooded during springtime floods	flooded during springtime floods	flooding durations increased in lower areas	flooding durations increased in lower areas

TABLE 10:
PROJECT EFFECT ON ANNUAL VOLUME DELIVERED TO THE SHERWOOD [illegible]
(Source: Output from the Canadian model using L. Darling
conservation pool at 1597)

YEAR	MONTHS UNDER 50/40*	ANNUAL VOLUME 50/50	ANNUAL VOLUME 50/40	DIFFERENCE	PROJECT EFFECT**	PERCENT OF [illegible]
1912	JAN.-DEC.	50277	47057	3220	3220	6.4
1913	JAN.-DEC.	32076	31564	512	512	1.6
1914	JAN.-SEP.	36765	29412	7353	4454	[illegible]
1915		2459	2267	192	0	[illegible]
1916		83599	66879	16720	0	[illegible]
1917		53368	42694	10674	0	0.0
1918		21554	17243	4311	0	0.0
1919		45790	45450	340	0	0.0
1920		71963	57570	14393	0	0.0
1921		13681	10945	2736	0	0.0
1922		55792	44634	11158	0	0.0
1923		85258	85086	172	0	0.0
1924		26319	25330	989	0	0.0
1925		97673	78139	19534	0	0.0
1926		23848	23767	81	0	0.0
1927	OCT.-DEC.	152656	135021	17635	6153	4.[illegible]
1928	JAN.-DEC.	92468	86645	5823	5823	6.3
1929	JAN.-SEP.	23281	22894	387	387	1.7
1930		24162	19330	4832	0	0.0
1931		2447	2431	16	0	0.0
1932		4225	4199	26	0	0.0
1933		34643	29395	5248	0	0.0
1934		16754	16754	0	0	0.0
1935		5994	4795	1199	0	0.0
1936		28333	22667	5666	0	0.0
1937		2467	2467	0	0	0.0
1938		23792	19033	4759	0	0.0
1939		45415	36332	9083	0	0.0
1940		4348	4317	31	0	0.0
1941		22388	19615	2773	0	0.0
1942		44330	35464	8866	0	0.0
1943		125562	100450	25112	219	0.2
1944	OCT.-DEC.	36173	33859	2314	2314	6.4
1945	JAN.-SEP.	7512	7476	36	36	.5
1946		38876	31101	7775	0	[illegible]
1947	OCT.-DEC.	92311	73849	18462	10476	[illegible]
1948	JAN.-DEC.	174768	164526	10242	10242	[illegible]
1949	JAN.-DEC.	39560	38506	1054	1054	[illegible]
1950	JAN.-DEC.	60871	60864	7	7	[illegible]
1951	JAN.-DEC.	105839	101888	3951	3951	[illegible]
1952	JAN.-DEC.	36695	36311	384	384	[illegible]
1953	JAN.-DEC.	104444	91828	12616	[illegible]	[illegible]
1954	JAN.-DEC.	47319	37855	9464	[illegible]	[illegible]
1955	JAN.-DEC.	148481	199223	-50742	***	[illegible]
1956	JAN.-DEC.	153517	183468	-29951	***	[illegible]
1957	JAN.-DEC.	27043	24027	3016	[illegible]	[illegible]
1958	JAN.-SEP.	[illegible]075	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 10 (con't.):

1959		13875	13875	0	[illegible]	[illegible]
1960		79765	76458	3307	[illegible]	[illegible]
1961		5940	5937	3	[illegible]	[illegible]
1962		12676	12231	445	[illegible]	[illegible]
1963		26060	20848	5212	[illegible]	[illegible]
1964		30439	24351	6088	[illegible]	[illegible]
1965	OCT.-DEC.	56555	53750	2805	[illegible]	[illegible]
1966	JAN.-SEP.	39047	31238	7809	[illegible]	[illegible]
1967		26346	25601	745	[illegible]	[illegible]
1968		13642	12084	1558	[illegible]	[illegible]
1969		175936	166963	8973	[illegible]	[illegible]
1970	OCT.-DEC.	121262	116186	5076	[illegible]	[illegible]
1971	JAN.-DEC.	53687	44581	9106	9106	[illegible]
1972	JAN.-DEC.	133722	147360	-13638	***	[illegible]
1973	JAN.-DEC.	10841	10841	0	0	[illegible]
1974	JAN.-DEC.	181733	189062	-7329	***	[illegible]

* The period when the evaporation sharing agreement would allow 60 percent of natural runoff to be retained in Saskatchewan.

** The project effect is the amount of water retained in Saskatchewan under the proposed evaporation agreement.

*** The hydrologic model predicts more water is delivered when the U.S. receives 40% of the natural runoff than when 50% is received. This logical inconsistency is attributed to flaws in model sensitivity.

TABLE 11:

[illegible] EFFECT ON ANNUAL VOLUME DELIVERED TO THE MANITOBA [illegible]
Source: Canadian model using L. Darling consv. pool at 1947

YEAR	MONTHS UNDER 60/40*	ANNUAL VOLUME 50/50	ANNUAL VOLUME 60/40	DIFFERENCE	PROJECT EFFECT**	PERCENT OF [illegible]
1912	JAN.-DEC.	123934	121266	2668	2668	[illegible]
1913	JAN.-DEC.	42087	42082	5	5	[illegible]
1914	JAN.-SEP.	21030	21030	0	0	[illegible]
1915		8311	8311	0	0	[illegible]
1916		88437	84253	4184	[illegible]	[illegible]
1917		21251	21251	0	[illegible]	[illegible]
1918		7089	7089	0	0	[illegible]
1919		33192	24514	8678	0	[illegible]
1920		44240	44240	0	0	[illegible]
1921		19128	16559	2569	0	[illegible]
1922		43326	43326	0	0	[illegible]
1923		109502	109102	400	0	[illegible]
1924		30274	30274	0	0	[illegible]
1925		83283	83283	0	0	[illegible]
1926		15972	15516	456	0	[illegible]
1927	OCT.-DEC.	218031	215342	2689	0	[illegible]
1928	JAN.-DEC.	150282	137137	13145	13145	3.7
1929	JAN.-SEP.	21352	17244	4108	4108	19.2
1930		39426	39426	0	0	0.0
1931		6255	6255	0	0	0.0
1932		7218	7164	54	0	[illegible]
1933		28974	28974	0	0	[illegible]
1934		6864	6864	0	0	[illegible]
1935		13477	13477	0	0	[illegible]
1936		12963	12963	0	0	[illegible]
1937		7611	7611	0	0	[illegible]
1938		7419	7419	0	0	[illegible]
1939		7080	7080	0	0	[illegible]
1940		13162	12309	853	0	[illegible]
1941		27864	26080	1784	0	[illegible]
1942		60804	58514	2290	0	[illegible]
1943		215872	214688	1184	0	[illegible]
1944	OCT.-DEC.	151321	151321	0	0	[illegible]
1945	JAN.-SEP.	78748	78748	0	0	[illegible]
1946		31868	31333	535	[illegible]	[illegible]
1947	OCT.-DEC.	78173	76642	1531	[illegible]	[illegible]
[illegible]	JAN.-DEC.	332833	293753	39080	39080	[illegible]
[illegible]	JAN.-DEC.	298989	298887	102	102	[illegible]
[illegible]	JAN.-DEC.	294373	293676	697	697	[illegible]
[illegible]	JAN.-DEC.	366700	366700	0	[illegible]	[illegible]
[illegible]	JAN.-DEC.	95612	92001	3611	3611	[illegible]
[illegible]	JAN.-DEC.	157159	149424	7735	7477	[illegible]
[illegible]	JAN.-DEC.	256911	246403	10508	[illegible]	[illegible]
[illegible]	JAN.-DEC.	324356	370557	-46201	***	[illegible]
[illegible]	JAN.-DEC.	286812	307758	-20946	***	[illegible]
[illegible]	JAN.-DEC.	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	JAN.-SEP.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]		[illegible]
[illegible]		[illegible]	[illegible]			[illegible]

TABLE II (con't.):

1961		13907	13907	[illegible]	[illegible]	[illegible]
1962		15311	15311	[illegible]	[illegible]	[illegible]
1963		42627	40681	1946	[illegible]	[illegible]
1964		58344	56562	1782	[illegible]	[illegible]
1965	OCT.-DEC.	37057	37057	0	[illegible]	[illegible]
1966	JAN.-SEP.	59668	59668	[illegible]	[illegible]	[illegible]
1967		58007	57951	56	[illegible]	[illegible]
1968		49707	48935	772	[illegible]	[illegible]
1969		503454	503135	319	[illegible]	[illegible]
1970	OCT.-DEC.	390009	375691	14318	[illegible]	[illegible]
1971	JAN.-DEC.	143897	139461	4436	4436	[illegible]
1972	JAN.-DEC.	327894	336211	-8317	***	[illegible]
1973	JAN.-DEC.	58227	58227	0	[illegible]	[illegible]
1974	JAN.-DEC.	580044	586161	-6117	***	[illegible]

* The period when the evaporation sharing agreement would allow 60 percent of natural runoff to be retained in Saskatchewan.

** The project effect is the amount of water retained in Saskatchewan under the proposed evaporation agreement.

*** The hydrologic model predicts that more water would be delivered when the U.S. receives 40% of natural runoff than when 50% is received. This logical inconsistency is attributed to flaws in model sensitivity.

TABLE 12:

LAKE DARLING WATER SURFACE LEVELS (FEET) ON NOV. 1.
(Source: Canadian model with L. Darling consv. pool at 1597)

YEAR	MONTHS UNDER 50/40*	ELEV. 50/50	ELEV. 50/40	DIFFER-ENCE	WITH PROJECT	PROJECT EFFECT**	HISTORI
1912	JAN.-DEC.	1596.2	1596.2	0.0	1596.2	0.0	
1913	JAN.-DEC.	1593.8	1593.8	0.0	1593.8	0.0	
1914	JAN.-SEP.	1590.6	1589.8	0.8	1590.6	0.0	
1915		1586.1	1586.1	.0	1586.1	0.0	
1916		1589.2	1587.5	1.8	1589.2	0.0	
1917		1586.9	1582.7	4.2	1586.9	0.0	
1918		1586.5	1583.8	2.7	1586.5	0.0	
1919		1585.5	1585.1	0.4	1585.5	0.0	
1920		1586.9	1586.9	0.0	1586.9	0.0	
1921		1586.9	1586.8	0.1	1586.9	0.0	
1922		1586.9	1586.9	0.0	1586.9	0.0	
1923		1591.9	1591.3	0.6	1591.9	0.0	
1924		1590.6	1590.1	0.5	1590.6	0.0	
1925		1591.1	1588.8	2.3	1591.1	0.0	
1926		1586.8	1586.8	0.0	1586.8	0.0	
1927	OCT.-DEC.	1593.5	1592.5	1.0	1592.5	-1.0	
1928	JAN.-DEC.	1597.0	1595.8	1.2	1595.8	-1.2	
1929	JAN.-SEP.	1592.2	1591.1	1.0	1592.2	0.0	
1930		1586.9	1586.9	0.0	1586.9	0.0	
1931		1583.3	1583.3	0.1	1583.3	0.0	
1932		1581.4	1581.3	0.1	1581.4	0.0	
1933		1584.0	1583.4	0.5	1584.0	0.0	
1934		1583.4	1583.1	0.3	1583.4	0.0	
1935		1582.1	1582.1	0.1	1582.1	0.0	
1936		1585.7	1584.3	1.4	1585.7	0.0	
1937		1583.7	1582.1	1.5	1583.7	0.0	1578.6
1938		1586.5	1584.6	1.9	1586.5	0.0	1580.6
1939		1586.2	1584.9	1.3	1586.2	0.0	1587.8
1940		1585.7	1584.7	1.1	1585.7	0.0	1583.1
1941		1586.9	1586.9	0.0	1586.9	0.0	1588.9
1942		1586.9	1586.9	0.0	1586.9	0.0	1593.0
1943		1592.4	1589.4	3.0	1592.4	0.0	1593.1
1944	OCT.-DEC.	1593.5	1590.9	2.7	1590.9	-2.7	1593.4
1945	JAN.-SEP.	1591.1	1587.8	3.3	1591.1	0.0	1589.0
1946		1590.5	1586.9	3.5	1590.5	0.0	1592.0
1947	OCT.-DEC.	1595.5	1592.4	3.1	1592.4	-3.1	1592.6
1948	JAN.-DEC.	1596.3	1596.3	0.0	1596.3	0.0	1594.0
1949	JAN.-DEC.	1593.7	1593.7	0.0	1593.7	0.0	1593.7
1950	JAN.-DEC.	1596.3	1596.3	0.0	1596.3	0.0	1595.1
1951	JAN.-DEC.	1596.6	1596.6	0.0	1596.6	0.0	1594.7
1952	JAN.-DEC.	1594.6	1594.6	0.0	1594.6	0.0	1594.1
1953	JAN.-DEC.	1596.6	1596.6	0.0	1596.6	0.0	1596.3
1954	JAN.-DEC.	1597.0	1597.0	0.0	1597.0	0.0	1594.8
1955	JAN.-DEC.	1595.9	1595.9	0.0	1595.9	0.0	1593.6
1956	JAN.-DEC.	1595.0	1595.0	0.0	1595.0	0.0	1594.5
1957	JAN.-DEC.	1593.3	1593.2	0.1	1593.2	-0.1	1592.6
1958	JAN.-SEP.	1588.1	[illegible]	[illegible]	1588.1	0.0	1592.0

TABLE 12 (con't.):

1959		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1960		1590.2	1583.3	[illegible]	1590.2	[illegible]	[illegible]
1961		1584.8	1584.2	0.7	1584.8	0.0	[illegible]
1962		1586.0	1585.8	0.2	1586.0	0.0	1587.2
1963		1587.3	1587.0	0.3	1587.3	0.0	1588.5
1964		1587.9	1586.9	1.0	1587.9	[illegible]	[illegible]
1965	OCT.-DEC.	1593.1	1592.6	0.5	1592.6	[illegible]	[illegible]
1966	JAN.-SEP.	1591.8	1590.3	1.5	1591.8	[illegible]	[illegible]
1967		1587.7	1586.9	0.7	1587.7	[illegible]	1592.1
1968		1585.8	1585.5	0.3	1585.8	0.0	[illegible]
1969		1591.7	1591.3	0.4	1591.7	0.0	[illegible]
1970	OCT.-DEC.	1596.6	1596.6	0.0	1596.6	0.0	1595.8
1971	JAN.-DEC.	1595.6	1595.6	0.0	1595.6	0.0	1594.9
1972	JAN.-DEC.	1596.7	1596.7	0.0	1596.7	0.0	[illegible]
1973	JAN.-DEC.	1592.6	1592.6	0.0	1592.6	0.0	1594.3
1974	JAN.-DEC.	1595.2	1595.2	0.0	1595.2	0.0	1595.1
1975							1595.1
1976							1593.7
1977							1590.8
1978							1596.0
1979							1594.3
1980							1593.8
1981							1592.9
1982							1595.3
1983							1595.1
1984							1593.1
1985							1595.1

* The period when the evaporation sharing agreement would allow 60 percent of natural runoff to be retained in Saskatchewan.

** Project effect is the difference between the "50/50" and the "WITH PROJECT" elevations.

agreement - to what degree will the agreement reduce water delivered to the U.S. during low flow periods and what will be the impact on water quality?

5.14 As indicated in paragraph 5.02 it is not possible to predict the exact amount of water than will be delivered to the U.S. at any one point in time, and it is not possible to predict the exact set of circumstances that will result in a water quality problem. Because Lake Darling is the most significant body of surface water on the Souris River, it serves an important water supply function; and water levels in the lake can serve as an indicator of potential water supply and related water quality problems during non-flood periods. Water levels below elevation 1592 are thought to increase the susceptability of the lake to winterkill, and at elevation 1592 the lake holds an estimated 2-year water supply for J. Clark Salyer Refuge. When the level of Lake Darling falls below elevation 1592 the potential for water supply and associated water quality problems on the Souris River are believed to increase appreciably.

5.15 Water surface elevations in Lake Darling with and without the evaporation sharing agreement were compared (table 12). The analysis shows that without the agreement, Lake Darling would have fallen below elevation 1592 in 36 of 63 years; while with the agreement, Lake Darling would fall below 1592 in 37 of 63 years. This analysis indicates that the evaporation sharing agreement would not have a significant effect on the number of years Lake Darling would be below the critical elevation of 1592, and as such, should not have a significant effect on overall water supply during low-flow periods. By not appreciably increasing the number of years that Lake Darling would be below elevation 1592, it is not expected that the evaporation sharing agreement would have any significant impact on the occurrence of water quality problems on the Souris River.

Aquatic Resources

5.16 Lake Darling - The proposed evaporation sharing agreement is designed to protect Lake Darling from water shortages through specification of elevation 1592 as a critical elevation below which Canada would not be allowed to retain extra water. Water levels below 1592 are thought to increase the susceptibility of the lake to winter fishkills (paragraph 4.22). At elevation 1592 Lake Darling also holds an estimated 2-years water supply for the J. Clark Salyer Refuge; hence, the evaporation sharing agreement includes language aimed at avoiding damages to both the Lake Darling fishery and its water supply functions.

5.17 Analysis of modelling results showing Lake Darling late fall elevations (table 12) indicates that the evaporation sharing agreement would increase the frequency of Lake Darling entering winter below elevation 1592 by 2 percent. This would not result in any significant impacts to the Lake Darling fishery, especially when considering the expected decline in the value of Lake Darling as a fishery resource under without project conditions (paragraph 4.90).

5.18 Souris River - The aquatic resources of the Souris River are primarily limited by low flow conditions which occur nearly every year during late summer, fall, and winter. Water stored in Lake Darling can be used to augment flows during low flow periods. As part of the Souris Basin alternative, the proposed evaporation sharing agreement would minimize effects during periods

of little runoff by insuring Lake Darling has sufficient water to augment low flows.

5.19 During moderate and high runoff years Saskatchewan would be allowed to take an additional 10% of the runoff, which they are expected to primarily take from the surpluses occurring during spring runoff. The retention of additional water during the spring runoff during the "wetter" years is not expected to have any significant effect on the Souris River aquatic resources.

Terrestrial and Wetland Resources

5.20 Floodplain Habitats (Wetlands, Floodplain Forest, Agland, and Grassland) - Under existing conditions most of the land adjacent to the Souris River downstream of Verendyre is subject to springtime flooding during moderate runoff years which does not result in economic damages. Under future without project conditions construction of the dams in Canada is expected to result in reduced flooding in the floodplain, in turn resulting in vegetation shifts adapting to the new conditions (paragraphs 4.95-4.99). Under with project conditions the evaporation sharing agreement would contribute to this trend towards reduced natural flooding of habitats in the Souris River floodplain.

5.21 Because the 1959 agreement does not dictate when Saskatchewan can retain their share of the runoff it is not possible to predict exactly when and how much they will retain in any given year. It is expected that Saskatchewan would retain the bulk of their water during spring runoff as that is generally the only time there is surplus water on the Souris River. It is also expected that Saskatchewan would retain the additional 10% granted under the evaporation sharing agreement from the spring runoff.

5.22 The retention of additional water under future without conditions as a result of Canadian dam construction and the retention of additional water under the evaporation sharing agreement would occur over the same time period and during the same runoff events. The impacts to floodplain habitats of additional water retention under future without conditions and for project purposes would occur synergerstically, and would be impossible to separate in any quantitative manner.

5.23 During the period 1959-1985 Saskatchewan retained 15% of the runoff by volume. Under future without conditions this is expected to increase to 50%. Over the long term the evaporation agreement is expected to result in the retention of an estimated additional 2.5% of water by volume (paragraph 5.07). While water volumes do not show the entire picture these figures do indicate that the impacts of the evaporation sharing agreement are likely to be relatively insignificant when compared to the changes that will occur under the future without condition of Canadian dam construction.

5.24 Wildlife Resources - The impacts to wildlife resource will go hand in hand with the impacts to floodplain habitats. As with the impacts to vegetation it would be impossible to try to separate the impacts of future without changes from those attributable to the evaporation sharing agreement. The effects on wildlife would be even more subtle as it expected the majority of floodplain wildlife would be able to adapt to some degree to a gradual change in the vegetative character of the floodplain. Over the long term species composition would adjust to the changing conditions.

5.25 As with the changes to habitat it is expected that the impacts to wildlife will be, on a relative scale, significantly greater from the projected future without changes than from the increment of change induced by the evaporation sharing agreement.

5.26 National Wildlife Refuges - Under existing conditions, management pools on the J. Clark Salyer Refuge are subject to avian disease problems and reduced vegetation management capability during low flow periods. Management problems on the refuge are expected to increase under future without-project conditions (paragraph 4.97).

5.27 The Souris Basin alternative evaporation sharing agreement should have no appreciable effects on the Upper Souris NWR because flows through that refuge during moderate runoff years are confined to the channel. The J. Clark Salyer Refuge should not suffer adverse effects to their management program because the evaporation agreement is designed to insure that Lake Darling contains sufficient water for J. Clark Salyer management needs.

5.28 Threatened and Endangered Species - Although drier conditions resulting from the proposed evaporation sharing agreement would affect resources used by threatened or endangered species, the resources would not be altered so that they would not be useful to these species. Furthermore, none of the affected resources are critical habitat for these species; hence, the effects during non-flood years of either alternative would be negligible.

Canadian Natural Resources

5.29 Under without-project conditions evaporation losses in Canada will make it difficult to maintain water levels in Rafferty and Alameda reservoirs which could result in water quality problems and exposure of large mud flats on the upstream ends of the reservoirs. Under with project conditions the evaporation sharing agreement would benefit Saskatchewan resources by allowing extra water to be retained in Canada thereby avoiding some of these adverse effects. The magnitude of beneficial effects could not be computed given existing hydrologic data.

5.30 The evaporation sharing agreement could exacerbate water shortage problems in the Manitoba portion of the Souris Basin. The impacts in Manitoba are expected to parallel those in the U.S. (refer to impacts described in preceding paragraphs), although Manitoba would continue to receive a minimum flow of 20 cfs as a result of existing agreements.

Cultural Resources

5.31 There would be no effect on cultural resources during non-flood years since the evaporation sharing agreement would primarily affect in-channel resources.

Recreation Resources

5.32 No significant changes in recreation resources would be expected to result for the changes in flows proposed in the evaporation sharing agreement.

Aesthetic Values/Visual Resources

5.33 No significant changes in visual or aesthetic values would be expected to result for the changes in flows proposed in the evaporation sharing agreement.

Social Reources

5.34 During non-flood years the only effects of the evaporation sharing agreement on social resources would be increased potential for a constrained water supply at Minot and some agricultural areas along the river (see paragraph 5.11).

ENVIRONMENTAL EFFECTS - FLOOD YEARS

HYDROLOGIC CHANGES

5.35 Primary hydrologic changes during flood periods are due to the floodwater release plan rather than the volume of water retained in Canada. The proposed project calls for controlled release of all flood events up to the 100-year flood. Water would be stored in Canada and released according to the flood operation plan.

IMPACTS TO SIGNIFICANT RESOURCES

General Description

5.36 Most of the environmental impacts of the two alternative flood control plans are a result of the alteration of flood flows rather than the alteration of flows during non-flood periods as described above. The flood operation plan (lowered flood peaks and prolonged durations) affects all floodplain resources (i.e. low lying areas are flooded for longer periods and the chance of flooding at higher elevations is significantly smaller). Most of the valuable wildlife habitat occurs in the lower portions of the floodplain; hence, the majority cf adverse effects result from prolonged inundation of the low-lying areas. Agricultural land may also be lost due to urbanization within areas protected from flooding.

5.37 Changes in the flow regime also affect the manageability of the National Wildlife refuges. Management on the J. Clark Salyer refuge is focused on water level regulation of shallow impoundments of the Souris River. Prolonging the duration of high flows prevents drawdown of these impoundments thereby disrupting the management cycle. The general impact at Lake Darling includes a pre-flood drawdown, and a delay in refilling of the lake dependent upon the size of the flood.

5.38 Impacts of the Souris Basin alternative are not much different from those of the Lake Darling alternative because the flood operation plan is basically the same for both. Some impacts of the Lake Darling plan are greater than those of the Souris Basin plan (e.g. raising Lake Darling would be required under the Lake Darling plan and is not part of the Souris Basin plan), while some impacts are less (e.g. the Souris Basin plan would have prolonged releases of 500 cfs during control of the larger floods, it would also require larger pre-flood drawdowns). Appendix 10 contains hydrographs

comparing existing and with project conditions for the Souris Basin alternative. Table 13 shows the length of extended 500 cfs releases at various stations with various sized flood events.

5.39 The analysis of potential impacts during flood years is summarized in the following paragraphs. The differences between the with and without-project conditions and impacts of the two alternatives are summarized for each of the significant resources previously identified (Section 4.0).

Water Quality

5.40 As discused in paragraphs 4.80 thru 4.86 construction of Rafferty and Alameda reservoirs have the potential for having substantial impact upon the quality of water entering the U.S. which can not be quantified without further studies. This in turn makes it difficult, if not impossible, to make any quantitative projections of the impact of flood storage and release.

5.41 The following have been identified as areas where the addition of flood storage and the subsequent release of the stored flood waters as proposed may have water quality effects:

a. Nutrients

b. Discharge of anoxic water

5.42 As stated in paragraph 4.82 the inundation of a new reservoir usually results in a substantial release of nutrients during the first 5-10 years of inundation. The proposed flood storage in Rafferty reservoir will increase the maximum flooded area from 12,050 to 15,400 acres, while at Alameda reservoir the maximum flooded area will increase from 3,300 to 5,470 acres. Assumming a simple straight line relationship it would appear that the addition of flood storage would result in a 35 percent increase in the amount of nutrients released over and above what will occur from construction of these reservoirs for water supply. This is a relatively gross estimation and ignores such factors as the seasonality of flood water storage, dilution by flood waters, nutrient cycling within the reservoir, and other factors.

5.43 It is expected that the release of additional nutrients due to flood water inundation will not be additive to that resulting from initial reservoir filling, but will occur in later years in small spurts with the large infrequent floods. The reasons for this are:

a. available hydrologic data indicates that it will take 5-10 years for the initial filling of the Saskatchewan reservoirs to full supply level. During this time some of the initial nutrient release from decomposing vegetation and newly flooded soils will take place.

b. the storage of flood waters above full supply level will likely not occur until after the Saskatchewan reservoirs are initially filled. While the storage of flood water above full supply level could occur with a large flood event during this initial filling period it is statistically unlikely.

c. storage of flood waters during the warm water months would occur only with floods of greater frequency than 20-year occurrence and only if the

Table 13: Cessation of 500 CFS Flow at Different Stations with Different Sized Flood Events

VERENDRYE

Flood Year	Frequency	Without Project	With Project	Change
1982	8-yr	12 Jun	12 Jun	0
1974	15-yr	15 Jul	25 Jun	-0.5 mo
1969	17-yr	22 Jul	22 Jul	0
1975	19-yr	25 Sep	30 Sep	+0.1 mo
1979	22-yr	9 Aug	9 Aug	0
1976	45-yr	12 Sep	5 Oct	+0.7 mo
1979 x 1.5	50-yr	8 Sep	30 Dec	+3.7 mo
1976 x 1.3	70-yr	15 Sep	1 Jan	+3.5 mo
1979 x 2.0	100-yr	15 Sep	30 Jan	+4.5 mo
1976 x 1.5	100-yr	30 Sep	30 Jan	+4.0 mo

BANTRY

Flood Year	Frequency	Without Project	With Project	Change
1982	8-yr	18 Jun	18 Jun	0
1974	15-yr	22 Jul	5 Jul	-0.5 mo
1969	17-yr	30 Jul	30 Jul	0
1975	19-yr	25 Sep	30 Sep	+0.1 mo
1979	22-yr	15 Aug	15 Aug	0
1976	45-yr	15 Sep	30 Oct	+1.5 mo
1979 x 1.5	50-yr	12 Sep	30 Dec	+3.6 mo
1976 x 1.3	70-yr	15 Sep	1 Jan	+3.5 mo
1979 x 2.0	100-yr	17 Sep	30 Jan	+4.5 mo
1976 x 1.5	100-yr	30 Sep	30 Jan	+4.0 mo

WESTHOPE

Flood Year	Frequency	Without Project	With Project	Change
1982	8-yr	25 Jun	25 Jun	0
1974	15-yr	30 Jul	15 Jul	-0.5 mo
1969	17-yr	25 Aug	25 Aug	0
1975	19-yr	30 Sep	30 Sep	0
1979	22-yr	20 Aug	20 Aug	0
1976	45-yr	15 Sep	30 Oct	+1.5 mo
1979 x 1.5	50-yr	15 Sep	30 Dec	+3.5 mo
1976 x 1.3	70-yr	20 Sep	5 Jan	+3.5 mo
1979 x 2.0	100-yr	20 Sep	30 Jan	+4.5 mo
1976 x 1.5	100-yr	30 Sep	30 Jan	+4.0 mo

Table 13: cont'd

FOXHOLM

Flood Year	Frequency	Without Project	With Project	Change
1982	8-yr	24 May	22 May	-0.06 mo
1974	15-yr	13 Jul	23 May	-1.6 mo
1969	17-yr	22 May	1 Jun	+0.3 mo
1975	19-yr	21 Jun	31 May	-0.7 mo
1979	22-yr	30 May	30 May	0
1976	45-yr	2 Aug	2 Aug	0
1979 x 1.5	50-yr	4 Sep	5 Dec	+2.9 mo
1976 x 1.3	70-yr	10 Sep	4 Jan	+3.7 mo
1979 x 2.0	100-yr	11 Sep	1 Feb	+4.6 mo
1976 x 1.5	100-yr	28 Sep	31 Jan	+4.0 mo

MINOT

Flood Year	Frequency	Without Project	With Project	Change
1982	8-yr	25 May	23 May	-0.06 mo
1974	15-yr	14 Jul	14 Jun	-1.0 mo
1969	17-yr	1 Jun	24 May	-0.3 mo
1975	19-yr	23 Sep	30 Sep	+0.2 mo
1979	22-yr	7 Aug	2 Aug	-0.1 mo
1976	45-yr	9 Sep	14 Sep	+0.1 mo
1979 x 1.5	50-yr	5 Sep	6 Dec	+2.9 mo
1976 x 1.3	70-yr	10 Sep	4 Jan	+3.7 mo
1979 x 2.0	100-yr	12 Sep	1 Feb	+4.6 mo
1976 x 1.5	100-yr	29 Sep	31 Jan	+4.0 mo

reservoirs were at fully supply level when the large flood event took place. Statistically the most this should occur would be 5 or 6 times in 100 years and then only if each large flood event occurred when the Saskatchewan reservoirs are at full supply level.

When a large infrequent flood does occur requiring storage of flood waters into the warm months above the full supply level of these reservoirs there would be a pulse of released nutrients from the inundated areas. If and when these releases occur and what effect they may have on the nutrient level of the water eventually reaching the United States is not possible to predict without extensive further study. Based on available information it is not expected that the effect would be significant due to the relative infrequency of occurence and the moderating effect the reservoirs themselves would have on reducing peak nutrient levels.

5.44 As discussed in paragraph 4.81 the Saskatchewan reservoirs may stratify and currently are proposed to have bottom discharges, which in turn raises water quality concerns with the discharge of anoxic water. The act of storing flood water in these reservoirs may effect whether or not the reservoirs will thermally stratify. The storage of the 100-year event in Rafferty would increase water depths at the dam from 51 feet to 63 feet and in Alameda would increase water depth at the dam from 79 feet to 95 feet. At present it is believed that the reservoirs will stratify with or without flood storage.

5.45 The release of stored flood waters may prevent stratification because of the proportionally large volume of water that would be released from the reservoirs when the larger flood events are stored. For example, with a 100-year event the stored flood waters would approximately equal the pre-flood drawdown volume of Rafferty reservoir. At Alameda the stored flood waters would be approximately three times the volume of the pre-flood drawdown pool. Without further modelling of these reservoirs it is not possible to accurately predict how the release of large amounts of stored flood waters will effect reservoir stratification.

5.46 The potential for the storage of flood waters to increase the release of anoxic water with effects being observed in the United States was evaluated from both the worst case and reasonably foreseeable perspectives. The worst case conditions would be the result of the following:

a. Rafferty and Alameda reservoirs stratified with anoxic hypoliminions in July and August prior to fall turnover.

b. Rafferty and Alameda reservoirs at full supply level when the storage of flood waters is required.

c. a. and b. occurring in the first 10 years of operation when Rafferty and Alameda are expected to have high BOD loadings due to the decomposition of inundated vegetation.

5.47 Table 14 shows when the release of flood waters would occur for some historic flood events. As can be seen from the table, stored flood waters would be excavated from the reservoirs for events smaller than approximately the 20-year event prior to the time of year these reservoirs would be expected to stratify and have anoxic hypoliminions. The 1975 event was an anomaly in

Table 14: Time Required to Evacuate Stored Flood Waters from Saskatchewan Reservoirs

Flood Event	Reoccurrence Interval (Yr.)	30-day Volume (Ac-Ft)	Storage above FSL begins Rafferty	Storage above FSL begins Alameda	Release of Flood Waters Complete Rafferty	Release of Flood Waters Complete Alameda
1982	8-year	140,200	27 Apr	16 Apr	15 May	12 May
1974	15-year	220,400	26 Apr	30 Apr	31 May	5 May
1969	17-year	248,300	19 Apr	17 Apr	21 May	18 May
1975	19-year	267,900	28 Apr	29 Apr	25 Oct	12 Sep
1979	22-year	289,300	26 Apr	3 May	5 Aug	13 Jul
1976	45-year	400,400	10 Apr	9 Apr	28 Oct	29 Jul
1979 x 1.5	50-year	433,900	25 Apr	27 Apr	6 Dec	19 Dec
1976 x 1.3	70-year	520,500	10 Apr	8 Apr	1 Dec	2 Dec
1979 x 2.0	100-year	578,600	27 Apr	24 Apr	5 Feb	20 Feb
1976 x 1.5	101-year	600,000	10 Apr	9 Apr	11 Jan	3 Dec

This table assumes both reservoirs at 1 meter below full supply level at beginning of the event. Assumed discharge of 500 cfs at Minot after 1 June.

that it was a late season rainfall induced event and not a typical snowmelt event. Thus, under the worst case scenario, the discharge of anoxic flood waters could occur during the late summer in approximately 5 of the next 100 years following project implementation.

5.48 If one of these worst case events were to occur in the first ten years of reservoir existence the waters may have a sufficiently high enough BOD load such that complete reaeration before the waters reached the United States would not take place. In such an instance there would be adverse effects on fish and other aquatic life in that reach of the Souris River from the border to the upper reaches of Lake Darling.

5.49 The potential for the worst case occurence is considered to be extremely small. The reasonably foreseeable condition is as follows:

a. It will take Saskatchewan 5-10 years to fill their reservoirs to full supply level.

b. Saskatchewan will have difficulty maintaining full supply levels significantly reducing the probability of them being required to store a large flood event on a full pool.

c. Because of the unlikelihood of the reservoirs being at fully supply level when a flood event occurs, it is expected that only flood events larger than a 30- to 40- year event will result in the release of stored flood waters into the late summer when the reservoirs could be stratified.

d. The release of large volumes of water from these reservoirs may prevent them from stratifying, eliminating potentially anoxic conditions.

e. Should the storage of large flood events result in the increased discharge of anoxic water, the 80+ river mile distance from Rafferty and 25+ river mile distance from Alameda to the United States border should allow for sufficient instream reaeration.

5.50 In summary, while there is potential that the storage of flood waters in Saskatchewan could result in adverse water quality effects in the United States, the probability of such an occurrence is considered remote enough as to be viewed as only speculative. The reasonably foreseeable effect is that the storage of flood waters will not have any appreciable effect upon the quality of Souris River water entering the United States.

5.51 The water quality in both Lake Darling and the Souris River can also be affected by changes in the erosion/sedimentation processes induced by the proposed flood operation plan. In order to determine potential adverse effects, an analysis of potential changes in the erosion/sedimentation rates was conducted using the following assumptions:

1. Erosion potential is greatest in the Souris River channel not the overbanks. Because of reduced water velocities and the presence of floodplain vegetation, the erosion potential of water outside the river channel is greatly reduced.

2. Erosion potential in the channel increases with the rate of discharge and is maximal at bank-full capacity (dominant discharge).

3. Velocities (erosion potential of the flow) do not change significantly in the river channel from bank-full to flood conditions.

4. Differences in the duration of flow between existing conditions and the proposed operation plan are greatest at 500 cfs, and 500 cfs is well below the bank-full discharge in most reaches of the river.

5.52 The analysis concluded that the proposed flood operation plan would not have a significant impact on channel capacity or erosion because it calls for only minor changes in the duration of flow above normal discharge rates. Instead of large increases in duration for flows at channel capacity, the proposed plan has small increases in the duration of flows in excess of the channel capacity but less than existing peak flows. The plan also calls for increases in the duration of lower flows (500 cfs range) that are less than the bank-full capacity of most reaches of the river. This plan allows for a reduction in flood damages caused by very large peak discharges while causing very little change in the duration of channel-capacity size flows. Because the proposed operating plan so closely resembles the existing conditions, no significant changes are anticipated in channel capacity or erosion.

Water Supply

5.53 The flood operation plan for either alternative would have no effect on the water rights along the Souris River.

Aquatic Resources

5.54 Given the scope of the aquatic resources in the Souris Basin, the lack of fishery data for much of the Souris River, and the uncertainty of future hydrologic events, it is not possible to evaluate the impacts of either the Lake Darling or the Souris River Basin plans in quantifiable terms. The discussion that follows identifies expected impacts in qualitative terms for both alternatives.

5.55 Both the Lake Darling and the Souris Basin plans would have short term impacts on the aquatic ecosystem associated with construction activities. These include dam construction or modification, modification of refuge impoundments, construction of refuge mitigation features, and levee construction at other project sites. Impacts would occur from direct habitat disturbance and from the temporary suspended solids increase usually associated with construction in or near the water. In general, these impacts would be of relatively short duration and localized in the area of construction.

5.56 Construction impacts on the aquatic ecosystem would be somewhat less with the proposed Souris Basin alternative than with the Lake Darling alternative because construction required at the Lake Darling dam would be less. In addition, a number of smaller features such as boat ramp relocations would not be required with the Souris Basin project. With proper controls neither alternative would be expected to have any significant construction related impacts on aquatic resources.

5.57 Lake Darling - Drawdown of Lake Darling for flood control operation would increase the potential for winterkill in Lake Darling under certain conditions. Both the proposed Souris Basin plan and the Lake Darling plan would have about the same degree of impact in this area. This effect would be minor in comparison to the expected increase in winterkill susceptibility associated with loss of volume to sedimentation and the Canadian retention of 50% of natural flows under without project conditions.

5.58 When Lake Darling is drawn down to accomodate flood waters there would be a lag time associated with the refilling of the lake versus what presently occurs (Table 15). This lag time in refilling could effect the spawning success of early spring spawners such as norther pike and yellow perch by altering the availability of suitable spawning habitat. The impact could be positive or negative depending on the level of the lake at any given time with any given flood event. In general however, the impact is expected to be negative as some spawning habitats would likely not be flooded until the post-spawning periods for these species.

5.59 This impact would most likely occur with the mid-sized flood events, e.g. the 10- to 45-year events. There appears to be no significant lag time with the larger flood events because of the large amount of water that must be dealt with. The exception in table 15 is the simulated 70-year event. However, with this event the reservoir would still have been filled by early April, the normal spawning season for early spring spawners. Based on expected flood frequencies the potential for impact due to preflood drawdown would occur approximately 8 years out of 100. While individual year classes would be affected, the relative infrequency of the impact leads to the conclusion that long term changes in the composition and productivity of the Lake Darling fishery should not be impacted.

5.60 Souris River - Both the proposed Souris River Basin and the Lake Darling projects would have extended summer-fall high flow releases following flood storage. These higher-than-normal flows in the Souris River would have both positive and negative effects on the aquatic ecosystem. The erosive effects of existing peak flood flows would be reduced; however, higher summer releases could exert a constant erosive force on the riverbanks at higher than normal elevations. This would result in disruptions to aquatic habitat as the river eroded and accreted in various areas to restabilize itself. In certain situations the river could become more turbid and carry a higher sediment load. On the other hand, the higher flows during late summer could improve fish habitat quality which is currently limited during late summer by low flows.

5.61 Extended flows associated with the proposed Souris River Basin project are expected to occur only a few more times per 100 years (less than 5) than would occur with the Lake Darling project. Given this relative infrequency and that extended flows can have both adverse and beneficial impacts, the difference in impact to aquatic resources of the Souris River from extended flows between the two alternative projects is not expected to be significant.

5.62 Both the Lake Darling project and the proposed Souris River Basin project would include a carp control barrier at dam 357 in J. Clark Salyer Refuge. The current proposal is an electrical barrier. No system can be guaranteed as 100 percent effective. However, studies during the Lake Darling

Table 15: Lag Time in Refilling Lake Darling to Elevation 1587 Associated with Various Flood Events

Flood Event	Frequency	Existing Conditions	With Project	Lag Time (days)
1982	8-yr	26 Apr	28 Apr	2
1974	15-yr	18 Apr	13 May	25
1969	17-yr	18 Apr	28 Apr	10
1975	19-yr	8 May	1 Jun	23
1979	22-yr	27 Apr	1 Jul	65
1976	45-yr	6 Apr	1 Jun	55
1979 x 1.5	50-yr	22 Apr	27 Apr	5
1976 x 1.3	70-yr	28 Mar	20 Apr	23
1979 x 2.0	100-yr	25 Apr	30 Apr	5
1976 x 1.5	100-yr	3 Apr	8 Apr	5

project indicated that this would be the most effective of the available options.

5.63 The risk of carp invasion would be slightly higher with the Souris River Basin project because it would involve high flow releases approximately 2-3 times per 100 years that would extend into the winter. This in turn would increase the survivability of carp in the Souris River during the winter below the J. Clark Salyer Refuge should they manage to pass the Wawanesa Dam during those high flow years.

Terrestrial and Wetland Resources

5.64 Table 16 summarizes the expected hydrologic changes associated with the Souris Basin plan as reflected in the hydrographs contained in appendix 10. These hydrologic changes will result in the types of impacts discussed for terrestrial and wetland resources below. As can be seen from the table these effects will vary from flood event to flood event but a general pattern of impact can be developed.

5.65 Grassland - During flood years without the project, grassland areas would be flooded at about the same frequency and duration as under current conditions. With either the Lake Darling or the Souris Basin plan lower flood peaks and prolonged durations at lower flows would decrease the frequency of flooding on grassland sites in the higher portions of the floodplain and prolong the duration of flooding on the lower grassland sites. In the upstream portions of the valley (upstream of Verendyre) grassland areas would be subject to only minor adverse effects from the flood operation plan under either the Lake Darling or Souris Basin plan. Channel capacity in the upstream reaches is large enough that most flows are confined to the channel and do not affect grasslands. The proposed project would alter the frequency at which channel capacity was exceeded, but the alteration would not be large enough to cause significant changes in grassland areas.

5.66 Unlike the upstream areas, grasslands in the downstream portion of the watershed would be subject to greater impact as a result of altered flood flows. Channel capacities below Verendyre are smaller than those in the upstream areas, and as a result grassland areas in the lower portions of the floodplain would be subject to longer periods of flooding and vegetation die-back.

5.67 Impacts to grassland would be somewhat greater under the proposed Souris Basin plan than under the Lake Darling plan. Control of the 100-year flood event under the Souris Basin plan would require 500 cfs releases throughout the entire growing season. Although this would result in prolonged inundation of grassland areas which would kill much of the vegetation, the long-term effects would not be great because grasslands recover rapidly and prolonged inundation would be a relatively rare occurrence.

5.68 A total of approximately 8,200 acres of grasslands in the Souris River floodplain could be affected by the proposed project. The impacts to grasslands were quantified to some degree in a HEP analysis (appendix 4) and accounts for approximately 7 percent of the quantifiable losses in habitat value of either the Lake Darling or Souris Basin alternatives. Grassland habitat values are being mitigated for out-of-kind with gains in wetland

Table 16. Summarization of Hydrologic Changes Associated with Various Flood Events

FLOOD EVENT	FREQUENCY	BORDER TO LAKE DARLING REACH	LAKE DARLING	LAKE DARLING TO J. CLARK SALYER REACH	J. CLARK SALYER REACH
1982	8-YR	a. Flood peaks reduced by approximately 35 percent b. Extended duration of 500 to 1500 cfs flows for 2-3 days in mid-May	a. No appreciable change	a. Flood peaks reduced by 10 to 20 percent b. No change to summer flows	a. Flood peaks reduced by approximately 20 percent b. No change to summer flows
1974	15-YR	a. Flood peaks reduced by approximately 55 percent b. Extended duration of 1500 to 2500 cfs flows for 3-5 days in mid-May c. Reduction in flows from 1500 to 500 cfs in late-May and early-June	a. Pre-flood drawdown advanced from mid-March to mid-February b. Filling of lake delayed from early April to early May	a. Flood peaks reduced by approximately 10-13 percent b. Substantial reduction in out of channel flows in late May c. Reduction in flows in early July	a. Flood peaks reduced by 10-20 percent b. Substantial reduction in out of channel flows in May and June c. Reduction in flows in late July - early August
1969	17-YR	a. Flood peaks reduced by approximately 40 percent b. Extended duration of 500 to 1500 cfs flows for approximately 5 days in mid to late May	a. No appreciable change	a. Flood peaks reduced by approximately 40 percent b. Extended duration of 500 to 1500 cfs flows for 3-10 days from mid-May to early June	a. Flood peaks reduced by up to 50 percent b. Extended duration of 500 to 3500 cfs flows for 2-5 days in late May to early June
1975	19-YR	a. Flood peaks reduced by approximately 55 percent b. Extended in-channel flows of 500 cfs throughout summer	a. Delay in filling of lake from early May to late May	a. Flood peaks reduced by approximately 20 percent b. No appreciable change in summer flows	a. Flood peaks reduced by 10 to 20 percent b. No appreciable change in summer flows

Table 16. Cont'd

FLOOD EVENT	FREQUENCY	BORDER TO LAKE DARLING REACH	LAKE DARLING	LAKE DARLING TO J. CLARK SALYER REACH	J. CLARK SALYER REACH
1979	22-YR	a. Flood peaks reduced by approximately 45 percent b. Extended duration of flows approximately 500 cfs over natural from mid-May to mid-August	a. Delay in filling lake from late April to early June	a. Flood peaks reduced by 10 to 20 percent b. Reduced in-channel flow in late June	a. Flood peaks reduced by up to 10 percent b. Reduced in-channel flow in July
1976	45-YR	a. Flood peaks reduced by approximately 60 percent b. Extended duration of flows approximately 1000 to 3000cfs over natural during May c. Extended duration of 500cfs flows from August to November	a. Preflood drawdown advanced from early March to mid February b. Delay in filling lake from late April to early June	a. Flood peaks reduced by 40 to 60 percent b. Reduced in-channel flow in August and September c. Extended 500 cfs flow from mid-September to late October	a. Flood peaks reduced by about 30 percent b. Extended 500 cfs flows in October
1979 X 1.5	50-YR	a. Flood peaks reduced by approximately 40 percent b. Extended duration of 500 cfs flows from mid June to late December	a. Delay fillin lake from early May to early June	a. Flood peaks reduced by 65 percent b. Flows reduced by about 500 cfs in early June c. Extended 500 cfs flows from early September to late December	a. Flood peaks reduced by 40 percent b. Extended 500 cfs flows from mid September to late December

Table 16. Cont'd

FLOOD EVENT	FREQUENCY	BORDER TO LAKE DARLING REACH	LAKE DARLING	LAKE DARLING TO J. CLARK SALYER REACH	J. CLARK SALYER REACH
1976 X 1.3	70-YR	a. Flood peaks reduced by approximately 60 percent b. Extended duration of 500 cfs flows from August through January	a. Higher lake level in February b. Delay filling lake from early April to early May	a. Flood peaks reduced by approximately 60 percent b. Extended duration of 500 cfs flows from mid September to early January	a. Flood peaks reduced by 25 to 50 percent b. Reduced in-channel flows in August c. Extended duration of 500 cfs flows from late September to January
1976 X 1.5	100-YR	a. Flood peaks reduced by 40 to 70 percent b. Extended duration of 500 cfs flows from mid July to February	a. Delay filling lake by about 15 days	a. Flood peaks reduced by approximately 70 percent b. Extended duration of 500 cfs flows from mid September to February	a. Flood peaks reduced by approximately 50 percent b. Extended duration of 500 cfs flows from late September to February
1979 X 2.0	100-YR	a. Flood peaks reduced by approximately 60 percent b. Increased flows in late May c. Decreased flows in late June d. Extended duration of 500 cfs flows from August through January	a. Increased lake level in January b. Delay filling lake by about 10 days	a. Flood peaks reduced by approximately 70 percent b. Increased flows in late May b. Extended duration of 500 cfs flows from October through January	a. Flood peaks reduced by about 40 to 60 percent b. Increased flows in early June c. Decreased flows in early July d. Extended duration of 500 cfs flows from October through January

habitat value through the construction of management features on the Upper Souris River and J. Clark Salyer National Wildlife Refuges.

5.69 Wetlands - Over 70 percent (960 AAHU out of 1330 AAHU) of the quantifiable impacts of the Souris Basin and Lake Darling plans stem from project effects on wetlands in the downstream portions of the watershed. The majority of these impacts (887 AAHU) result from disruptions of wetland management capabilities on the J. Clark Salyer Refuge.

5.70 With the project, wetland values would be expected to decline due to lost manageability caused by the flood operation plan. Management capabilities would be disrupted on the J. Clark Salyer Refuge whenever the release of flood waters extends the duration of flows so that pools targeted for drawdown cannot be lowered to desired levels. In order to lower pools, flow on the Souris River must be below approximately 100 cfs in early June. The prolonged 500 cfs releases required under the proposed flood operation plan would make it impossible to follow the management plan on the refuge during approximately one of every ten years. Under the Lake Darling plan, 500 cfs releases would extend into August during a 25-year event (the largest flood controlled by the Lake Darling plan). Since the proposed Souris Basin plan would control the 100-year event, the 500 cfs releases could be prolonged for one year on the rare large floods.

5.71 Although primary wetland losses occur on the Salyer refuge, there are other upstream areas which would experience wetland losses. Most notably, 215 acres of wetland would be affected by the one foot raise in the Lake Darling conservation pool required under the Souris Basin plan (paragraph 3.11). The raise would inundate the wetlands, but would not destroy them; hence, the net effect of this action is not as dramatic as might be thought (17 AAHU lost out of 132 total wetland AAHU in this area). The Lake Darling plan would have greater impact on wetlands around Lake Darling. Storage of floodwaters four feet above current levels would inundate 1779 acres of wetlands at the upstream end of Lake Darling resulting in losses of 123 AAHU out of 532 AAHU of total wetland habitat available in the impact area.

5.72 The Souris Basin plan could affect up to 38,000 acres of wetlands in various degrees depending upon the individual flood event. Of this total approximately 1,600 acres lie within areas that would be affected by the prolonged releases of 500 cfs flows associated with large, infrequent flood events. Most of these wetlands lie within the J. Clark Salyer NWR. Losses in wetland habitat value are being compensated for through the construction of management features on the Upper Souris River NWR and J. Clark Salyer NWR to improve wetland quality.

5.73 The proposed Souris Basin plan is in compliance with E.O. 11990 (Protection of Wetlands) since this plan has the least effect on wetlands of any of the other alternative plans. The proposed action would not enhance wetland drainage, and wetland impacts have been avoided to the extent practicable. Mitigation measures are included in the proposed plan to replace project-induced wetland losses (see paragraph 3.16). The construction of mitigation features would impact up to 15 and 6 acres of wetland habitat on the Upper Souris and J. Clark Salyer refuges respectively. These impacts would be associated with construction of compensation features and the obtaining of

borrow material, and would be temporary in nature. No long-term loss of habitat values provided by these wetlands is expected to occur.

5.74 Floodplain Forest - Losses of floodplain forest also represent a significant portion of the total impacts of both the Lake Darling and Souris Basin plans (69 AAHU out of 1330 AAHU). As with grassland habitat, losses of floodplain forest occur primarily in the downstream portions of the basin and result from prolonged inundation during flood operation.

5.75 Without the project, the amount of water released to the U.S. will decline as Canada develops the potential to retain 50 percent of natural flow. This will result in drier conditions in the floodplain and will eventually cause species composition in the forests to shift toward a drier community.

5.76 Under with project conditions, forests would still succeed toward a drier community in non-flood years, but low-lying areas would be subject to increased duration of inundation during flood periods. The result may be very destructive to floodplain forests because the shift to a community better adapted to dry conditions would leave that community more vulnerable to vegetation losses resulting from inundation during flooding. The magnitude of the losses is very dependent upon the frequency of inundation in floodplain forests. With major flood events woody vegetation in the 5,000 cfs floodplain would be inundated throughout the growing season, with or without the project. Additional inundation with the prolonged releases of 500 cfs is not expected to impact the survivability of woody vegetation because it would occur during the dormant season.

5.77 Approximately 10,000 acres of floodplain forest could be impacted by the alteration of flood flows with the proposed project. As with other habitats the impact would vary with flood event. Of this total approximately 60 acres lie within areas that would be inundated with the extended releases of 500 cfs flows. Losses in forest habitat value are being compensated for out-of-kind through the construction of features to improve wetland habitat values on the Upper Souris River and J. Clark Salyer NWR.

5.78 Agricultural Lands - Agricultural lands would be subject to the same hydrologic influences described for grassland habitat types. Losses would occur with either alternative along the downstream portions of the river where some of the prolonged releases of flood water would inundate agland adjacent to the river. The actual loss of agricultural production due to flooding is not expected to be great because normal agricultural practice would be disrupted only one out of ten years on the average.

5.79 The Souris Basin plan would have more impact than the Lake Darling plan on agricultural land in the vicinity of Minot. Since the Souris Basin plan would control the 100-year flood, it would remove development restrictions in areas above the 5000 cfs floodplain. An analysis conducted for the Burlington dam study indicates that housing demand is such that 1000 acres of agricultural land around Minot would be converted to housing if protection from the 100-year event is provided.

5.80 This impact evaluation assumes that there would be conversion of acres of agland to urban uses in the vicinity of Minot, however the [illegible] time and location of the conversion are not known. Furthermore

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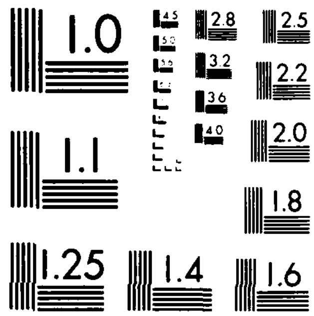

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conversion of agland will be dictated by many other influences in addition to those related to flood protection projects; hence, conversion is not primarily dependent on the proposed action. For these reasons an evaluation of the project with respect to the Farmland Protection Policy Act (FPPA) is not warranted.

5.81 Wildlife Resources - The wildlife resources of the Souris River Valley would suffer as a result of vegetation losses associated with either flood control alternative. Floodplain forests and wetlands provide breeding, winter cover, and feeding areas for many species including deer, furbearers (mink, muskrat, raccoon, etc.), rabbits, squirrels, skunks, most species of waterfowl, pheasants, grouse, and other bird species. The vegetation losses described above would cause decreases in the populations of animals using the vegetation resource. In addition, wildlife that normally use floodplain areas during summer and fall would be displaced during those times these areas are inundated by extended releases of stored flood waters.

5.82 Effects of the flood protection plans on waterfowl use of the refuges were given special consideration. Flood protection plans would result in loss of habitat management capabilities on the Salyer refuge which could impact waterfowl populations through loss of breeding habitat, feeding areas, and resting areas within the Salyer marshes. It has also been postulated (appendix 1, page 15) that the proposed release plan would stimulate waterfowl to overwinter on the Salyer refuge thereby increasing their susceptibility to disease and predation.

5.83 The latter concern stems from the possibility that release of floodwater during the winter months (required on large infrequent floods) would cause open water areas downstream of the dams on the Salyer refuge which could stimulate waterfowl to overwinter. Overwintering habitat must provide a food source and a source of open water; hence prolonged floodwater releases must occur with unusually low snowfall in order to stop migration. The chance that a mild winter would occur in conjunction with prolonged release of flood water is approximately 1 in 1000. Even if the effects on waterfowl were dramatic, the chances of occurrence are so small that the overall effect on waterfowl populations would be negligible.

5.84 National Wildlife Refuges - The majority of the project impacts on the two National Wildlife Refuges would occur in two areas: (1) on the Salyer Refuge as a result of prolonged floodwater releases; (2) at Lake Darling as a result of water level fluctuations.

5.85 Under the Lake Darling plan, storage of floodwaters up to elevation 1605 would cause habitat losses due to inundation of large areas periferal to the lake. Operation of the reservoir for flood control would also be contrary to its original authorized purpose (water supply and waterfowl production), although the current authorization would change that purpose (see paragraph 2.03). The Lake Darling plan would also affect operation of the J. Clark Salyer refuge through alteration of flows during flood events. Prolonged releases of floodwater would affect water management capabilities within the refuge thereby affecting waterfowl production.

5.86 The Souris Basin alternative would have less impact on Lake Darling, but greater impact on the water management capabilities on the Salyer Refuge.

Since this plan would not require a four foot raise of Lake Darling it would not inundate refuge habitat adjacent to the lake. The Souris Basin plan would, however, require more prolonged spring drawdowns within Lake Darling and as a result could have greater effects on fish spawning and fish populations in the Upper Souris NWR.

5.87 Prolonged 500 cfs releases associated with the Souris Basin plan would also affect wetland and wetland management capabilities on the Salyer refuge, and may also cause erosion of nesting islands in pools 320, 326, and 332. The effects on the refuges could not be quantified due to the unpredictability of large flood events, both in magnitude and how these one-time events will effect habitat.

5.88 Of the quantifiable losses in habitat value associated with the Souris Basin alternative, approximately 71 percent occur on the Upper Souris River and J. Clark Salyer NWR (969 our of 1330 AAHU). Because all of the proposed mitigation features are located on the refuges, current estimates are that the refuges themselves will be compensated approximately 123 percent for their quantifiable losses (1188 AAHU gain/969 AAHU loss).

5.89 Threatened or Endangered Species - The bald eagle, peregrine falcon, and whooping crane may use the Souris River Valley for feeding and resting during migration. These species could stay in the area for anywhere from a few minutes to a few days and would require a source of food plus resting areas. The bald eagle and peregrine falcon require small mammals, birds, or fish for food plus trees or cliffs for roosting. Whooping cranes are omnivorous, eating a variety of foods from grains to fish. For resting, whooping cranes require areas of shallow water (mud flats or sandbars).

5.90 In addition to the migratory uses by the eagle, falcon, and crane, the piping plover has been recorded as a breeding species in this portion of North Dakota. The plover is known to breed on sandbars and other bare-soil areas near water. Nests have also been found on levees and on disturbed areas near sewage lagoons.

5.91 A biological assessment of potential impacts to endangered or threatened species was conducted for the Lake Darling 4-foot raise project during the impact studies for that project. The U.S. Fish and Wildlife Service concurred with the determination that the Lake Darling project would have no adverse impact upon protected species of their critical habitat.

5.92 The U.S. Fish and Wildlife service informed the St. Paul District that a separate biological assessment would not be required for the Souris Basin plan (Appendix 8) because of all of the past coordination and study on the Burlington Dam and Lake Darling projects, and the similiarity of the Souris Basin plan to the Lake Darling project. They recommend that potential impacts to threatened and endangered species be addressed in this EIS, and that their review of this document would complete Section 7(c) coordination requirements.

5.93 The Souris Basin plan is not expected to have any impacts upon protected species or their habitat. The Souris Basin plan will require less construction at Lake Darling and will not require the raise of Lake Darling thus reducing further the potential for any construction related impacts. Operationally, the Souris Basin plan differs from the Lake Darling project in

that it will result in extended releases of 500 cfs flows with highly infrequent flood events (expected occurrence less than 5 times per 100 years). These infrequent, extended 500 cfs releases are not expected to have any effect on protected species because no critical habitat has been identified in the Souris River 500 cfs floodway, nor has any special use by protected species been identified.

Canadian Natural Resources

5.94 The proposed Souris Basin plan calls for storage of floodwater in Rafferty and Alameda reservoirs. Storage in Rafferty reservoir would require inundating a maximum of 3,500 additional acres of land surrounding the reservoir, while storage in Alameda would require inundating a maximum of 2160 additional acres. Many habitat types including wetlands, grasslands, and shrublands, would be damaged or lost as a result of inundation during flood storage. Habitat losses in vicinity of the reservoirs would displace or change use patterns by wildlife species (waterfowl, furbearers, deer, etc.) in the area.

5.95 Since the impacts of floodwater storage occur in Canada, and since the province of Saskatchewan is preparing environmental documents addressing the Canadian portions of the project, there is some question as to which of the Canadian impacts are attributable to the Souris Basin plan and must therefore be addressed in this document, The legal aspects of this issue are covered in Executive Order 12114 of 4 January 1979 (Environmental Effects Abroad of Major Federal Actions) which states that a formal analysis of the environmental effects must be conducted on all projects which "significantly affect natural or ecological resources of global importance" (E.O. 12114 Sec. 2-3(d)). Furthermore, COE regulations implementing E.O. 12114 contains an exemption from requirements of the regulation for actions which cause no significant harm to resources of global importance (32 CFR part 197; Enclosure 2, Sections B.2. and C.3.a.(1)). The Souris Basin Development Authority has prepared an environmental impact statement for the proposed Rafferty Reservoir. They proposed a supplement in 1988 to address the impacts of the proposal Alameda Reservoir.

5.96 The only resources in the project area which might be considered globally important are migratory birds and endangered species. Migratory birds would be affected by habitat losses in the flood pools of the Canadian reservoirs, however the effects are mostly due to displacement of birds to surrounding habitats rather than project-induced mortality. Furthermore, inundation of large areas of the floodplain would occur only rarely (i.e. once every 15 years) and most of the valuable habitat types would survive and be usable during all but the very large floods (once every 50 years). Endangered species use of the area around the Canadian dams is restricted to migration periods and would not be affected by the proposed flood control plan. Since project features in Canada would have no significant effects on globally significant resources, the proposed action is exempt from the requirements of E.O. 12114 and a detailed analysis of the impacts to Canadian natural resources is not required.

5.97 The Lake Darling alternative for provision of flood control would have no effect on Saskatchewan resources.

5.98 The primary effects in Manitoba of either flood control plan result from decreases in flood peaks and prolonged discharges of stored flood water. In Manitoba the effect is beneficial for the agricultural areas (the predominant land use) in higher portions of the floodplain and is detrimental in the lower areas. Manitoba indicates they can accomodate (zero damage) up to 600 cfs at any time except for an area about 6 miles long just downstream of the border, which has a channel capacity of 150 cfs. This area is predominantly pasture. At 1,000-1,100 cfs pretensive row crop damage begins, and at 4,000 cfs urban flooding at Melita begins. The effects of prolonged flooding would be worse with the Souris Basin plan than for the Lake Darling plan because control of the 50 to 100-year events would require prolonged release of 500 cfs for a major portion of the year.

5.99 The impacts on the natural resources in Manitoba would not result in significant impacts on resources of global importance. Localized habitat changes resulting from prolonged flooding of low-lying areas would displace some species, but is not expected to significantly affect migratory bird populations or endangered species.

Cultural Resources

5.100 This section discusses the impacts to significant archeological and historic sites found along the Souris River above Lake Darling and along the shoreline of Lake Darling. Potential impacts occur as a result of changes in flood frequency, flood duration, and in the potential for erosion.

5.101 Flood Frequency - The overall frequency of flooding with the Canadian dams in place and with flood storage provided is substantially decreased over existing conditions. In accordance with the proposed flood operation plan (paragraph 3.10) all sites located at elevations above that which would be impacted by flows of 4000 cfs at Sherwood, would no longer be inundated. At releases below 2000 cfs (as measured at Sherwood), flow would basically remain within the channel and no impacts to archeological and historic sites would be realized. Between 2000 cfs and 3200 cfs, cultural resources may or may not be impacted, depending upon the size of the release.

5.102 Significant sites 32RV23, 32RV101, and 32RV440 would no longer be flooded under controlled conditions. Four significant sites would be affected by 2000 cfs to 4000 cfs flows under controlled conditions. Site 32RV15 would be affected near the 2000 cfs release rate as this site is located very close to the existing river bank. Site 32RV415 is a small site located at an elevation near the 2000 cfs release rate. Site 32RV429 would be impacted at all elevations between the 2000 cfs and 4000 cfs release rate as this site covers a large area at various elevations. Site 32RV437 would also be affected by flows near the 2000 cfs release rate. Site 32RV441, the Renville County Park, will be protected from flood damages by construction of a levee surrounding the structures in the park. Construction of this levee will protect the site from deterioration by flooding under both existing conditions and that of the proposed project. A number of other significant sites could be identified as a result of the survey work yet to be accomplished between the Canadian border and the northern boundary of the Powers Elevation survey. Based on downstream surveys, it is anticipated that between 10 and 15 additional prehistoric sites will be identified in this area. Of these sites, two to three could be eligible for the National Register of Historic Places,

and, because of the narrowing width of the upstream valley, any larger sites may fall within the 4,000 cfs channel.

5.103 Significant sites along the shoreline of Lake Darling were not previously affected by flooding and would not be affected by the proposed plan. The closest sites above normal pool elevation of 1596 are sites 32RV417, 32RV419, 32RV420, and 32RV422, all of which are at elevation 1615. A number of sites around Lake Darling were discovered during the University of North Dakota survey which was during a low water period. These sites were located at elevations below 1595, and are now below the normal pool elevation of 1596.

5.104 Flood Duration - For flood events that affect significant sites above Lake Darling and along the shoreline of Lake Darling, duration of flooding may be the same or increased by a few days with the project.

5.105 Potential for Erosion - Erosion potential at significant resources located above the 4000 cfs flood plain would be greatly decreased from the existing conditions as flows no longer will reach this level under controlled conditions. The greatest potential for erosion is at Lake Darling where normal pool elevation will be increased to 1597. Areas of Lake Darling that have eroded in the past may continue eroding at an increased rate or begin eroding again since a prime factor affecting erosion has been changed. However, this increased potential for erosion may be offset by controlled flows into Lake Darling. With the Canadian dams in place and with flood storage potential, both uncontrolled and controlled flows into Lake Darling are reduced in size. For all flood events, the degree of fluctuation in the reservoir would be less with the proposed plan when compared to existing conditions.

5.106 Resources Downstream of Lake Darling - There would be a beneficial impact upon downstream resources with the Canadian dams in place. During smaller floods (i.e. 10 to 25-year events) flooding would be maintained within the present channel. All controlled floods up to the 100-year event would reduce the effects of downstream flooding.

5.107 Borrow Areas - Borrow areas will not be surveyed until they have been identified by the construction Contractor. At the time they are identified by the Contractor, they will be coordinated with the State Historic Preservation Officer to determine the need for further survey work. Should any sites be located during the survey, the borrow areas will not be approved for use by the construction Contractor.

Recreation Resources

5.108 Renville County Park - Although the frequency of damaging floods would be reduced with the Souris Basin alternative as opposed to the Lake Darling alternative, this is not expected to have a significant effect on the parks future. Interviews with park users and property owners concluded that flooding is not perceived to be so serious that they cannot live with it as they have in past.

5.109 The increased level of protection could accelerate the development of platted but undeveloped lots adjacent to the park.

5.110 Baker and St. Mary's (Silver) Bridges - With-project conditions for either alternative are not expected to significantly affect recreational use occurring at either bridge fishing area.

5.111 Souris Valley Golf Course - Golf course damage, lost revenues, and lost recreation occasions would be reduced with both alternatives because of the reduced occurrence of high flows. Both alternatives would substantially reduce the frequency of 5000 cfs flows that completely close the golf course.

5.112 Flows at or above 2500 cfs that impact portions of the course would also be reduced in frequency. Although flows exceeding 2500 cfs can occur after May 15, their frequency is projected to be significantly reduced.

5.113 Increased frequency and duration of 500 cfs flows would not affect golf course use by inundation. The long-term effect of 500 cfs flows on the bank erosion issue identified by the park board is not expected to be significant because the hydraulic conditions are not expected to change relative to existing conditions.

5.114 Upper Souris National Wildlife Refuge - Recreational facilities within the refuge would not be significantly affected by the project. The Fish and Wildlife Service is proposing operating the pool at a level one foot higher than the current level. This elevation raise would not affect the use of the pool boat launching ramps which are operable at even higher elevations.

5.115 Drawdown of Lake Darling during flood operation would have minimal effect on recreation use because it will occur prior to peak summer use.

Aesthetic Values/Visual Resources

5.116 The project would not have an appreciable effect on the valley's visual resources. The proposed one foot raise at Lake Darling would have only very minor effects on visual elements when the pool is at it's highest level. The pool raise should help reduce visual effects for drought conditions, reduced runoff years resulting from the evaporation sharing agreement, and flood operation drawdowns.

5.117 Lower pool levels will result in mudflat areas which would be a visual change from the shoreline conditions of the normal pool. The duration and frequency of these levels are not expected to depart significantly from without-project conditions. Significant permanent visual change is not anticipated.

Social Resources

5.118 The social resources which are significantly affected by either the Lake Darling or the Souris Basin alternatives are transportation; national defense; and social cohesion. Although housing, employment, and education are not significantly affected by either alternative, a discussion of these locally and nationally important resources is included.

5.119 Areas of social impact which must be evaluated under Section 122 of PL 91-646 include those which are not significantly affected by either alternative: business and home relocations; public facilities and services;

regional growth; and employment (which is nonetheless briefly discussed). The following Section 122 impact areas which are significantly affected by one or both alternatives, are included in the discussion of social cohesion: cohesion, community growth and development, property values, and tax revenues.

5.120 Flooding - In terms of how often certain flows would occur, Table 13 shows the changes which the Souris Basin alternative would have made, compared to what was actually experienced, and also compared to what the proposed four-foot raise of Lake Darling would have accomplished, for three areas along the U.S. portion of the Souris.

5.121 At Renville County Park, although the Souris Basin alternative would have yielded flows at or above 500 cfs during August and September more often than actually occurred, the critical damage point of 2,000 cfs would have been reached or exceeded less often, for all seasons. Thus there is no net damage to these properties, due to the Souris Basin alternative. However, the park also will not be provided a 100-year level of protection, which it would have received under the Lake Darling raise plan, by a levee and diversion protecting against Lake Darling's increased impoundments under that plan.

5.122 At Minot, flows would have been at or above 500 cfs more often, with the Souris Basin alternative, during September through November. But the critical damage point of 5,000 cfs would have been reached or exceeded less often, for all seasons, than historically happened. At Minot, the Souris Basin alternative will significantly improve flooding conditions, as well as public health and safety. Development within the present floodplain will become less costly and legally permitted, should restrictions be removed for the 100-year floodplain. Property values should also slightly improve in that case, thereby improving the city's revenue position.

5.123 And at Verendrye, 500 cfs would have been reached or exceeded more often, during September through November, than historically happened, but the critical damage point of 1,500 cfs would have been seen less often, for all seasons.

5.124 Housing, Employment, and Education - A worst-case analysis of housing needs, employment effects, and education impacts, was conducted in 1984. It found that, during the construction of a four-foot raise of Lake Darling project (including Velva and all other improvements) there should be no negative impacts on local housing. The analysis assumed that all workers were new to the region (not already living in the Minot area) and that the new workers would primarily reside in Minot and commute to the various work sites. Those years requiring the greatest number of employees would therefore require housing for 210 new workers (possibly with families) on the average, with 310 as the maximum number of new workers at any time during these years. Minot had adequate unused residential capacity as of Novemeber 1982: 246 residences for sale, 57 rental units vacant, and 63 mobile home units available.

5.125 Using the same maximum number of workers to be supplied entirely from the local labor force, all 310 could easily come from the North Dakota Region 2 construction industry unemployed (852 in 1981, using North Dakota's value of 38 percent of unemployed workers being in the construction industry). State and Region 2 unemployment rates were at 5.0 percent in 1981, near the 10-year average.

Table 17

Number of years during the period of 1936 to 1984 that flows equaled or exceeded the limits setforth below within dates given below

	R.C. PK.			MINOT			VERENDRYE		
	EX.	+4	CAN	EX.	+4	CAN	EX.	+4	CAN
at or above ZERO Damage (cfs)		2000			5000			1500	
15 May - 15 May	14	14	8	4	4	1	17	15	11
16 May - 1 Jun	3	3	2	2	1	0	11	9	5
during Jun	1	1	0	0	0	0	8	5	1
during Jul	0	0	0	0	0	0	1	1	0
during Aug	0	0	0	0	0	0	0	0	0
at or above 5,000 CFS									
15 Mar - 15 May	8	8	2		see above		4	4	2
16 May - 1 Jun	0	0	0		see above		[illegible]	3	0
at or above 2,500 CFS									
15 Mar - 15 May	14	14	6	8	7	5	6	6	6
16 May - 1 Jun	3	3	2	6	5	1	5	5	3
at or above 500 CFS									
during Jun	12	12	3	16	10	8	18	16	10
during Jul	6	6	2	9	8	6	9	9	8
during Aug	0	0	1	2	5	2	3	6	3
during Sep	0	0	1	0	0	2	0	0	2
1 Oct - 1 Dec	0	0	0	0	0	1	0	0	1

EX. - existing conditions
+4 - Lake Darling raised 4 feet
CAN - existing Lake Daring with two F/C dams in Canada
○ - worse off than existing
△ - same as existing (other than 0)

5.126 For impacts on educational resources, the worst case analysis assumed that all workers were new to Ward County and that their families included 415 children (using the Ward County average). Only if all childrean belonged to grades 7-8 would there be a strain on the Minot schools (junior high excess capacity was 241 in 1983); all other school levels had ample capacity.

5.127 Transportation - Lake Darling Plan: During construction of this alternative, local roads would bear heavy loads, causing a deterioration in road conditions. Damages would be repaired by the federal contractors. A one-year detour, using Baker Bridge, would be necessary while the dam is raised. This detour would add about 12 additional miles per vehicle crossing.

5.128 Table 14 shows anticipated transportation conditions, after project completion of the Lake Darling plan, for the bridges from the dam upstream to the Canadian border. As only the dam bridge (County 6) would be raised, it is the only crossing which would experience less frequent inundation, and it is the only one which would be inundated for a shorter period of time. Although very large floods such as the "100 year flood" are infrequent, whenever one occurs, all bridges between the dam and the border would be unusable. Some bridges currently closed for a few days or weeks would be closed, with this alternative, for weeks or months. The Soo Line tracks would be closed for three months, and Highway 5 would be unusable by the heaviest military transports for nearly five months, before the roadbed is dry enough for those loads. These closures are likely to begin following floods in spring, when access across the river for agriculture and for certain types of military activities is most vital. Transportation for schoolchildren and teachers, for farmers with livestock, equipment, and land on both sides of the Souris, for people crossing through the region on business or social activities, would become more time consuming and costly.

5.129 Souris Basin Plan: There would be no significant change from the present, or from the future without-project condition.

5.130 National Defense - Lake Darling Plan: Although floods large enough to close Highway 5 to the largest military vehicles only have the chance of occurring once in 30 years, such floods would have significant effects on the United States' ability to maintain readiness of the nuclear weapons under Minot Air Force Base control. (a) Response times to repair weapons or to halt and correct sabotage at the remote sites would be greatly increased. (b) Stress on all personnel would increase, as they would often travel for much longer periods of time before and after their actual jobs are accomplished. (c) The chance of some missions being unachievable would also be greater, due to the combination of icy road conditions, bridge closures, and short daylight hours available for the transport and escort of nuclear weapons. These factors would act together to weaken the reliability of the Nation's military preparedness.

5.131 Souris Basin Plan: There will be no significant change from the present, or from the future without-project, condition.

5.132 Social Cohesion - Lake Darling Plan: This alternative was designed to minimize the effect on **private ownership** of land, although some downstream agricultural land would require flowage easements, and residences on such land would have to be removed. In terms of **locus of impacts**, there would

Table 18. Expected Project-Caused Changes in Bridge Inundations Under the Lake Darling Alternative

	Present Daily Volume	Primary Uses	Percent of Crossings for Given Use	Inundated More/Less Frequently	Inundated once every x years: Old Freq. x=	New Freq. x=	Duration of Inundation Longer/Shorter?	For 100-year Flood Event, Days With Water on Road: Old	New
Lake Darling Dam Road (County Road 6)*	300	Oil	30	Less	20	PMF	Shorter	26	0
		Local Auto	25						
		Military	/						
Grano Crossing*	250	Farm Products	25	More	35	25	Longer	15	148
		Oil	25						
		Military	/						
Soo Line Railroad*	160 cars/wk	Farm Products	/	More	100	30	Longer	7	92
State Highway 28*	120	Farm Products	35	More	200	40	Longer	0	22
		Military	/						
		Local Auto	25						
Dam 41	15		/	More	1	1	Longer	40	220
State Highway 5*	440	Through Traffic	40	More	40	30	Longer	2	22**
		Military	/						
Renville City Park Crossing	116		/	More	10	1	Longer	35	200
Renville County Road 9 (FAS 3809)*	70	Farm Production	30	Same	20	20	Longer	5	20
Barber Bridge	65		/	Same	10	10	Same	35	35
Bluell Bridge	92		/	Same	10	10	Same	35	35
FAS 3804	72		/	Same	10	10	Same	35	35

/ Extimates not provided by county.
* Local preference to modify.
** 146 days would be required before heavy defense vehicles can use the crossing.

definitely be the perception that Minot was receiving flood control benefits, while upstream and downstream areas would bear the impacts. Local **costs** would be $3,182,000 (local first costs, excluding the Velva component, using October 1987 price levels) which would create considerable strain on the local and/or state **tax bases**. **Water supply** availability would be unchanged from the future without flood control situation.

5.133 Souris Basin Plan: As with the other alternative, some downstream agricultural land would require flowage easements, and residences on such land would have to be removed, affecting **private ownership** patterns to some extent. In terms of **locus of impacts**, with this alternative, most of the the upstream impacts would be in Saskatchewan. About the same downstream impacts would exist as for the Lake Darling 4-foot raise, with somewhat worse consequences in those infrequent years requiring a greatly extended release period. Local **costs** would be $7,920,000 (local first costs, excluding Velva component, using October 1987 price levels; local interests would also be responsible for cost increases due to changes in currency exchange rates abd with inflation) with a more severe effect on local and state **tax bases**.

5.134 Floodplain Development - Since the Souris Basin plan would provide protection from the 100-year flood, it would remove current restrictions on floodplain development in the city of Minot and in areas above the 5000 cfs floodplain. Analyses conducted under the Burlington Dam and Lake Darling studies indicates that development pressure is such that 1000 acres of floodplain agricultural land in the vicinity of Minot would be developed as a result of removing the floodplain restrictions. This development would occur slowly (approximately 10 acres per year) so that the full 1000 acres would not be developed for 100 years.

5.135 Executive Order 11988 prohibits the expenditure of Federal money on a project which would induce floodplain development unless there are no practicable alternatives which would avoid the development. The proposed Souris Basin plan is in compliance with the Executive Order because there are no practicable alternatives which provide 100-year protection and induce less floodplain development. The Lake Darling alternative would not induce any development since it would not provide protection from the 100-year flood. Alternatives which provide less than 100-year protection are not considered adequate due to the amount of flood damages which still occur.

5.136 Renville County Park - The most obvious effect of the project on this heavily used park would be the provision of 100-year protection against present flooding levels. This change provies both physical protection for property and legal redefinition of the floodplain for development and use. However, these effects are not seen as particularly important by most users of the park, who mostly feel that flooding is not significant.

5.137 The salient issue for most park users is that the park continue to be useable in its customary patterns. Alternatives were developed, screene, and revised in response to users' concerns and in cooperation with the FWS. To maintain the park's existence, the evacuation alternative was deopped, in favor of a protective levee. To maintain road access through the park and the valley, a Texas-style crossing was put through the diversion channel. This crossing would not be usable for some time after a 100-year flood, but or non-flood years it would only be unusuable in spring. To maintain boat access

between the park and the upstream section of levee. To prevent Federal acquisition of 3-1/4 acres of private property, the west end of the levee was realigned onto FWS refuge lands, with FWS cooperation.

6.00 PUBLIC INVOLVEMENT

Early Scoping and Coordination

6.01 Flood control measures in the Souris River Basin have been studied for many years (paragraph 2.01) and as a result affected individuals and agencies are well informed regarding most of the issues related to the current study. Issues which have been extensively coordinated include the proposed flood operation plan downstream of Lake Darling, the major aspects of the mitigation plan, and the principle of storing floodwater in Canada.

6.02 Comments on the current study were requested in a scoping letter sent to interested individuals and agencies on 8 May 1986 (responses are included in appendix 2). In general these comments focused on issues which were also important in the Lake Darling four-foot raise study or which were related to potential international effects of storing floodwater in Canada (paragraph 2.05).

6.03 To date, no formal public meetings have been held to present the proposed plan to concerned citizens. Meetings have not been held because an agreement between the province of Saskatchewan and the Corps of Engineers regarding operation of the Canadian dams during floods has not yet been reached. Public meetings will be held once a flood operation agreement is reached.

Required Coordination

6.04 EIS Review - This draft will be filed with the Environmental Protection Agency and distributed to the public for a 45-day public review period, which will begin when a notice of availability appears in the Federal Register. That notice should appear 1 or 2 weeks after the initial public distribution of this EIS. The EIS or a notice of its availability will be sent to all concerned agencies, individuals, and public repositories according to the list in appendix 3. Comments received will be responded to and will be used in preparation of the final EIS. Appropriate coordination with various agencies and other concerned parties will continue throughout the study.

6.05 Fish and Wildlife Coordination - A Fish and Wildlife Coordination Act report submitted by the U.S. Fish and Wildlife Service under the provisions of the Fish and Wildlife Coordination Act is in appendix 1 of this EIS, which also contains FWS recommendations and the Corps responses.

6.06 Consultation with the FWS over endangered species has been maintained throughout the Burlington Dam and Lake Darling studies. One new threatened species (piping plover) has been added to the list for the Souris Basin project. The effects on all threatened or endangered species are assessed in the EIS and will be coordinated with the FWS to fulfill the requirements under Section 7 of the Endangered Species Act.

6.07 Before the proposed project could be implemented a memorandum of agreement between the FWS and COE must be developed to cover transfer of money between the agencies (dam safety money and cost sharing for the carp control structure) and the delineation of operational and maintenance responsibilities. The FWS must also determine the compatibility of project

features with the purposes of the affected National Wildlife Refuges. These agreements and determinations will be made once discussions with Canada over the operation plan have been completed.

6.08 <u>Cultural Resource Coordination</u> - The Souris Basin study has been coordinated with the National Park Service, the North Dakota State Historic Preservation Officer (SHPO), and the Advisory Council on Historic Preservation. Initial coordination of this project was conducted in June 1985. The North Dakota SHPO responded in a letter dated May 28, 1986. The St. Paul District responded to these concerns in a letter dated 25 June 1986, stating that survey and assessment of Canadian sites would be conducted under the authority of the Heritage Resources legislation of Saskatchewan. The North Dakota SHPO subsequently requested the advise of the Advisory Council on Historic Preservation (letter dated July 16, 1986). On 29 August 1986 the Advisory Council requested that the Corps investigate to determine its responsibilities for historic properties under Section 106 of the National Historic Preservation Act of 1966, as amended, for properties located in the United States, and the Advisory Council offered its assistance in fulfilling responsibilities under Section 402 of the Act for properties in Canada. This EIS addresses issues raised by the North Dakota SHPO and the Advisory Council on Historic Preservation. Coordination of the results of surveys completed for the Canadian dams will continue with the above agencies as the information is made available to the St. Paul District by the Souris Basin Development Authhority. The North Dakota SHPO has stated that their comments on the Souris River Basin Project will be provided to the St. Paul District upon completion of their review of this document. Their comments will be included in the final NEPA document. Continued coordination with the North Dakota SHPO will be conducted on the results of the surveys to be completed in the Spring of 1988.

PUBLIC VIEWS AND RESPONSES

6.09 There is general acknowledgement throughout the Souris Valley that residents need flood damage reduction as soon as possible and that a preferred solution would provide protection from the 100-year flood. Public opinion also holds that flood protection measures should be acceptable to both those benefited and those adversely affected by the construction of those measures. The formulation of the Souris Basin project has been sensitive to all the public concerns and is an effort to satisfy as many of those concerns as possible within technical, economic, social, and environmental limitations.

6.10 The following public issues had a major influence on the formulation of the recommended plan:

1. The desire by local interests to minimize Federal property acquisitions and population displacement necessary to implement project features, especially in the Renville County Park feature.

2. The potential project impacts on the fish and wildlife resources, recreation resources, and management of the Upper Souris and J. Clark Salyer National Wildlife Refuges.

3. To the extent possible potential impacts from water losses due to evaporation on the Canadian reservoirs should be minimized.

4. Formulating the Lake Darling Dam operating plan was a prominent Souris Valley issue. Upstream interests and the Fish and Wildlife Service desired a rapid drawdown of the flood pool, while downstream interests generally favored a slow drawdown to minimize the rate and volume of water passing through the areas downstream of the dam. A compromise plan was negotiated between the two opposing interests in January 1983. The proposed flood operation plan is the same as the compromise plan with the exception of some modifications required during the larger infrequent flood events (see paragraph 3).

SOURIS RIVER BASIN PROJECT
LIST OF PREPARERS

NAME	DISCIPLINE/EXPERTISE	EXPERIENCE	ROLE
Mr. David Berwick	Archeology/Cultural Resources Management	9 years cultural resources management and EIS studies, St. Paul District; 2 years cultural resources management, Memphis District	Effects on historical, architectural, and archeological resources
Ms. Susan Foley	Engineering/Civil	3 years Corps of Engineers 7 years other engr. experience	Study Co-manager
Ms. Suzanne Gaines	Sociologist	7 years EIS studies, St. Paul District	Effects on social resources, institutional relationships
Mr. Dennis Holme	Water Quality	11 years water quality studies, St. Paul District	Effects on water quality
Mr. John Kittelson	Biology/Wildlife	7 years EIS studies, St. Paul District	Effects on wildlife resources, vegetation, prime farmlands; preparation of EIS; habitat evaluation and mitigation plan formulation
Mr. Martin McCleery	Engineering/Civil, Water Resources	13 years, project management, St. Paul District	Study Co-manager
Mr. Gary Palesh	Biology/Fisheries	13 years EIS studies, St. Paul District	EIS Coordinator; effects on aquatic resources
Mr. John Shyne	Biology/Fisheries	10 years EIS studies, St. Paul District; 2 years aquatic ecology research, USEPA	Effects on carp distribution and fishery resources
Mr. Russ Snyder	Landscape Architect	7 years resource planning, St. Paul District; 5 years private sector	Effects on recreation, aesthetics, and related resources

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APPENDIX 1

Fish and Wildlife Coordination Act Report
and
COE Responses to FWS Recommendations

United States Department of the Interior
FISH AND WILDLIFE SERVICE
1500 CAPITOL AVENUE
BISMARCK, NORTH DAKOTA 58501

DEC 12 1986

Colonel Joseph Briggs, District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Briggs:

This fish and wildlife report provides an assessment of the Souris River Flood Control Project, North Dakota. It addresses the effects of the selected plan on fish and wildlife resources, and conveys recommendations which are designed to prevent, lessen or compensate adverse effects to these resources and is for your use in preparing the Environmental Impact Statement. It has been prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). It is also consistent with the intent of the National Environmental Policy Act of 1969 (P.L. 91-190: 83 Stat. 852-856). Comments on the conclusions and recommendations by the North Dakota Game and Fish Department (NDGFD) are contained in the attached letter dated December 5, 1986.

Previous pertinent letters and reports by the Fish and Wildlife Service (FWS) on Minot Flood Control alternatives, the Burlington and Lake Darling projects, and the present Canadian Dams proposal are:

December 16, 1976	Analysis of Lake Darling 4-foot Raise with Burlington
April 25, 1977	Burlington Reservoir Report
September 4, 1981	FWS Position on Lake Darling Project
August 24, 1982	Planning Aid Information for Programmatic EIS & GDM Supplement
December 29, 1982	Instream Flow Needs & Reservoir Fishery Analysis
January 13, 1983	FWS Position on Reservoir Operation Plan
June 7, 1983	Preliminary Analysis & Planning Information for Phase I GDM
June 27, 1984	Lake Darling Report (4-foot raise)
January 3, 1985	FWS Position on Legal and Institutional Constraints
June 6, 1985	Prereconnaissance Study - Canadian Dams, Preliminary Report

October 11, 1985	DOI Comments on DES & Design Memorandum No. 3, Lake Darling Dam
November 13, 1985	Supplement to Lake Darling Report
November 27, 1985	Planning Aid Information - Reconnaissance Report on Flood Reduction Alternatives
May 30, 1986	Planning Aid Information for Reconnaissance Report - Canadian Dams
June 3, 1986	Scoping Comments for Draft EIS - Canadian Dams Supplement

The project consists of the construction of two reservoirs in Canada, reconstructing the outlet of the FWS's Lake Darling Dam, and providing local flood control measures at selected locations along the valley. Altered river flows resulting from this project will affect refuge lands at Upper Souris and J. Clark Salyer National Wildlife Refuges (NWRs).

Our recommendations and associated costs for mitigating and compensating project-induced fish and wildlife losses are consistent with the Presidential Directive of June 1978 on environmental quality and water resources management. That directive states:

> In all project construction appropriation requests, agencies shall include designated funds for all environmental mitigation required for the project and shall require that mitigation funds be spent concurrently and proportionately with construction funds throughout the life of the project.

DESCRIPTION OF THE AREA

The Souris River originates in southern Saskatchewan, flows southeast to Velva, North Dakota, then generally north to join the Assiniboine River in southern Manitoba. The U.S. portion of the river is 358 miles in length, with a drainage basin of 9,000 square miles; 371 miles of river and 15,000 square miles of the basin are in Canada. The average gradient is approximately 0.6 feet per mile. The valley varies from narrow (about 1 mile wide) and steep (200 feet) in the upper (ground moraine plain) part of the U.S. Loop, to very wide and undefined in the Souris Lake Plain (from Verendrye to Manitoba). The upper valley and the narrow riverine corridor are heavily wooded except where impounded. The principal tributaries influencing flows in the U.S. portion are: the Des Lacs River (1,050 square mile drainage area), Wintering River, Cut Bank Creek, Deep River, Willow Creek, Stone Creek and Boundary Creek. With the exception of the Des Lacs River, these larger drainage areas enter in the lower glacial lake plain.

Natural communities identified by the North Dakota Heritage Program include primary stream, fen, fescue prairie, lowland woodland, sand prairie, tall grass prairie, oak woodland and aspen/birch woodland. Other natural communities known to be present are: wet meadow, shallow marsh, deep marsh, permanent open water, mixed grass prairie, midgrass prairie, ravine woodland and wetland thicket.

The 1973 list of natural areas (Kantrud, 1973) included 14 areas in the Souris Basin. They included such features as bogs, sand dunes, riparian forest, upland forest and islands. The North Dakota Natural Areas Registry includes two 1986 additions, the Towner and Sweet Flag Bogs in McHenry County along the Souris River.

Three major National Wildlife Refuges occupy parts of the primary rivers of the basin; one on the Des Lacs and two on 80 miles of the Souris. Minot is the only major urban area. Land use in the remainder of the basin is agricultural, consisting primarily of small grains, sunflowers, hay and pasture. Agricultural drainage, both by individual and group projects such as legal drains and watershed projects, has eliminated about 220,000 acres, or one-third of the prairie wetlands in the U.S portion. This very large increase in the contributing area, plus Canadian drainage, has greatly increased total flows in the Souris. Along with the increased flows, sediment, nutrient and pesticide loads have increased.

The Souris River watershed includes predominantly glacial ground moraine and lakebed deposits. Interspersed with these are outwash, inwash and terrace deposits along the drainageways. A small portion of the Turtle Mountains, a stagnation or collapse moraine deposit of high local relief is included. The climate is continental, characterized by cold winters, warm summers, short growing seasons and moderate precipitation occurring principally during the growing season.

DESCRIPTION OF THE PROJECT

Flood Control Project Works - The flood control works in Saskatchewan, Canada. and North Dakota, United States of America, will include the following:

1. **Saskatchewan Works:**

   a. **Construction of Rafferty Dam, an earth-filled, rock-faced dam approximately 62 feet high and 2,370 feet between river banks, on the Souris River, 10 kilometers northwest of Estevan, Saskatchewan.** The purpose of the reservoir would be cooling water for Shand Thermal Station, downstream flood control, water supplies for Weyburn and Estevan, and irrigation for agricultural interests.

   b. Construction of Alameda Dam ,an earth-filled, rock-faced dam approximately 82 feet high and 4,500 feet between river banks, on Moose Mountain Creek near the towns of Alameda and Oxbow, Saskatchewan. The purpose of the reservoir would be primarily spring flood storage to complement operation of Rafferty Reservoir, municipal water source, agricultural irrigation and recreation.

c. The operation of storage in Boundary Dam at Estevan, Saskatchewan.

d. All costs for construction, rights-of-way acquisition, engineering, design, supervision, inspections, administrative, operation, and maintenance will be paid by Saskatchewan Power Corporation or other non-federal Canadian interest. The United States of America's expense for this project will be a one-time (perpetual life) contribution for the purchase of specified flood storage in the reservoirs and their operation for flood control in the United States in an amount not to exceed $41.1 million (October 1985), to achieve 1 percent chance flood protection at Minot, North Dakota.

2. North Dakota Works:

a. Lake Darling Dam

(1) Modification of the gated outlet works for flood control operation.

b. Operation and Mitigation requirements:

(1) Upper Souris Refuge:

- Provide heaters and actuators on Dam 96
- Upgrade Dam 96 gated structure
- Provide water supply to Ponds 96 A and B
- Provide water supply to Pool 87
- Restore water control capabilities to Pools A, B and C, as required

(2) J. Clark Salyer Refuge:

- Provide carp control velocity barrier for large flows and electric weir for low flows
- Provide heaters and actuators on all five dams (320, 326, 332, 341 and 357)
- Raise service roads, scenic trails, boat and canoe launch and exit sites
- Upgrade and raise Dam 326*
- Upgrade and raise Dam 332*
- Upgrade and raise Dam 341*
- Add low-flow structures on Dam 320 for improved circulation
- Construct potholes in wet meadow areas

*Includes acquisition of breakout points.

(3) Downstream urban levee improvements for maximum 5,000 cfs release:

- Subdivision areas between Burlington and Minot
- Sawyer
- Velva

(4) Rural downstream measures for areas affected by the Lake Darling operating plan

(5) Flood warning system for Gassman Coulee

c. Manitoba:

Compensation for areas affected by the overall operations plan.

EVALUATION METHODOLOGY

No new evaluations were done for this project. Impacts of flood control operations below Lake Darling are identical to those evaluated for the Lake Darling 4-foot raise, for the 25 year frequency event and all more frequent events (Lake Darling Project FWCA Report and EIS). Time constraints did not allow for detailed studies to be made on impacts on reduced water supply, less frequent flood events, and impacts above Lake Darling. Canadian and State Water Commission modeling was used to estimate water supply impacts. The Corps of Engineers provided hydrographs and water surface profiles for use in estimating impacts from infrequent flood events throughout the system.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

The Souris Basin and refuge resources have been described in numerous documents during this and previous studies. An overview follows:

> The impact area for this study consists of the United States portion of the Souris River Basin, some 9,320 square miles in nine counties. The principal habitats for fish and wildlife include riverine wetland, natural and impounded palustrine and lacustrine wetland, native woodlands, native and tame grasslands, and cultivated lands. Sixteen natural communities and 14 natural areas have been identified in the basin (FWCA Report - June 1984). The varied habitats are interspersed along the valley in linear fashion. This factor contributes to a high degree of utilization by wildlife.
>
> Significant sport fisheries are present in Lake Darling and the Souris River. The principal species are northern pike, walleye, yellow percn and smallmouth bass. From April 30 through September 5, 1983, this use totaled about 41,000 fishing hours in Lake Darling alone.

The Souris basin wetland and migratory bird resources are of international importance. They include about 400,000 acres of prairie pothole wetlands and about 25,000 acres of marsh habitat on the river in Upper Souris and J. Clark Salyer NWR's.

Annual duck and goose production on the two NWR's averages 20-30,000 and about 1,000, respectively. Migration populations of ducks, geese, cranes and swans may often range from 100-200,000. J. Clark Salyer NWR also provides habitat of critical importance for molting dabbling ducks. More than 250 bird species (most of which breed there) and 39 animal species have been recorded. The wildlife diversity includes a variety of waterbirds, raptors, furbearers, game species and songbirds.

Three endangered species, bald eagle, peregrine falcon and whooping crane, may occur in the basin during migratory periods. Whooping cranes may use large, shallow wetlands and adjacent grain fields during stopovers. Bald eagles and peregrines are most likely to be found near riverine, lacustrine, and large wetland habitats. The piping plover is listed as a threatened species in North Dakota. Piping plovers breed on isolated beaches, sparsely vegetated islands and sandbars, and the shorelines of alkaline lakes. Plover breeding has been recorded at Lake Darling.

Mitigation Policy

The affected lands on both NWR's correspond to Resource Category 2 of the U.S. Fish and Wildlife Service Mitigation Policy. The Designation Criteria are: "Habitat to be impacted is of high value for evaluation species and is relatively scarce or becoming scarce on a national basis". The mitigation goal is: "No net loss of in-kind habitat value". The remaining affected habitats (the riverine corridor) fall under Resource Category 3 - "High to medium value for evaluation species and is relatively abundant on a national basis," with a goal of "no net loss of habitat value while minimizing loss of in-kind habitat value".

EVALUATION OF ALTERNATIVE PLANS

Fourteen flood control plans, including no action, were evaluated by the Corps of Engineers in 1977. The present study was restricted to the previously described project. Certain alternatives were discussed and compared again for a Reconnaissance Report (FWS Planning Aid Letter of November 27, 1985).

Without A Plan

Future conditions in the absence of any Souris River Flood Control Plan were considered, regarding changes in habitat quantity and quality.

Aquatic Resources

A 27-year history of river flow volumes entering the United States was compiled from records at Sherwood, North Dakota. Since 1959, when the Interim measures provided that half of the natural flow at Sherwood is the U.S. share, the recorded flows entering the U.S. have averaged nearly 85 percent of the estimated natural flows. In 8 years, the recorded flows exceeded 100 percent of the estimated natural flows, probably due to the influence of drainage projects in Canada. Flows from drainage projects are not counted as natural flows. In only 4 of 27 years was the U.S. volume less than 60 percent; 8 years were less than 70 percent (Table 1).

Table 1

Annual Volumes
May 7, 1986

Year	Recorded at Sherwood	Natural Flow at Sherwood	Recorded as % of Natural	50% of Natural Flow
1959	17,158	26,677	64.3	13,338
1960	90,104	126,263	71.4	63,131
1961	3,976	7,750	51.3	3,875
1962	10,007	18,218	54.9	9,109
1963	19,330	41,529	46.5	20,764
1964	38,260	49,780	76.9	24,890
1965	81,160	88,269	91.9	44,134
1966	56,770	63,434	89.5	31,717
1967	36,030	44,378	81.2	22,189
1968	12,150	22,700	53.5	11,350
1969	300,600	280,259	107.3	140,130
1970	188,292	180,313	104.4	90,157
1971	101,900	88,744	114.8	44,372
1972	160,349	169,928	94.4	84,964
1973	10,290	12,547	82.0	6,274
1974	308,000	287,095	107.3	143,548
1975	388,800	315,408	123.3	157,704
1976	629,123	526,482	119.5	263,241
1977	10,752	12,955	83.0	6,478
1978	102,442	131,805	77.7	65,902
1979	377,039	333,753	112.9	166,877
1980	19,930	27,885	71.5	13,943
1981	12,060	18,070	66.7	9,035
1982	172,500	175,840	98.1	87,920
1983	144,700	129,400	111.8	64,700
1984	9,629	14,822	65.0	7,411
1985	37,884	55,488	68.3	27,744
1986				
Median	56,770	63,434		31,717
Lower 1/4	12,150	22,700		11,350

Based on this record (1959 through 1985), a review of available information and the likelihood of continued drainage into the river, we conclude that the most probable foreseeable future condition, without a plan, is that the U.S. will continue to receive substantially more than 50 percent of the natural flows. Some increased water usage will probably be balanced by increased drainage.

Continuation of the natural reservoir aging process, augmented by point and nonpoint discharges, will result in slow degradation of the aquatic environment in Lake Darling. Radical changes in land use would be required to substantially alter this scenario. The river environment is subject to countervailing man-induced changes. Continued wetland drainage will increase total flows, sediments, nutrients and agricultural chemical inputs. New sewage treatment facilities at Minot and other towns should result in fewer releases of effluent during the critical low-flow periods. The recent trends in reduced tillage of croplands should reduce soil erosion into the watercourse. However, more chemicals may be applied to the land, thereby increasing the amounts available to enter runoff. On balance, water quality is expected to decline, with periodic fishkills likely. Water quality will increase during spring runoff and after heavy rains.

Terrestrial Resources

Significant land-use changes are not expected in the watershed, although limited flood-plain residential development will still occur and agricultural clearing in the Turtle Mountains will continue. Grassland resources are relatively stable in the watershed. Unless large scale irrigation development occurs, soil, moisture and topographic conditions will restrict large scale land conversions. Private grassland will be stable to slightly lower in quality as a result of grazing use. Refuge grasslands are subject to active management which will maintain or improve quality in the long term.

Flood-plain forest resources are projected to remain relatively constant in acreage, with minor declines in habitat value due to use and succession on private lands. The refuge acreages of forest are increasing above Lake Darling. Habitat values will increase to year 10 through management of Upper Souris NWR, then remain stable or slowly decline. At J. Clark Salyer NWR, management actions are expected to offset successional changes for a stable forecast.

The reduced tillage trends on croplands will result in more available wildlife cover and food, thereby increasing their habitat values.

Wetland Resources

The Souris Valley marshes and their wildlife are affected by water quantity, water quality and timing of flows. The last factor is very important as it affects waterfowl production. Records show a direct impact from high flows (above structure capacity) at J. Clark Salyer NWR occurring after May 1. The later the flows, the more production is curtailed. The recent guideline of the State Water Commission to require delaying releases from drainage projects until flood peaks are subsiding will increase this problem. Annual fluctuations in marsh habitat value are large. In 1975, duck production at J. Clark Salyer NWR

was estimated at only 4,633. In 1982, the estimate was 13,662. This is one indicator of habitat quality. The prognosis is for the wide annual fluctuations to continue with long-term averages declining.

Alternative Operating Plans

A. Flood Control Operating Plan

A Conceptional Operating Plan for Rafferty, Alameda, Boundary and Lake Darling Reservoirs for flood control was developed by the Corps of Engineers. It was revised somewhat to accommodate concerns of the FWS and other water users and affected residents, within the necessary constraints to achieve flood protection for the 100-year flood at Minot.

The operating plan is based on predicted 30-day flood volumes at Sherwood. System operating guidelines were developed to operate the total system to the benefit of the system as a whole. In order to avoid unnecessary drawdowns at Lake Darling, the preflood drawdowns will be based only on the uncontrolled volume at Sherwood. If the Canadian dams are below full service level, the extra amount of storage will be used before requiring drawdown of Lake Darling. It is likely that no drawdown of Lake Darling will be required for frequent events.

Lake Darling releases through the 25-year event will be the same as were planned and analyzed for the 4-foot raise (June 1984, FWCA Report). For the less frequent events, maximum releases from Lake Darling would be extended until all of the reservoirs' flood water storage is evacuated. This could extend until sometime in March, for a 100-year event.

The currently proposed Lake Darling flood operating plan by the Corps of Engineers is as follows:

Date	Maximum release from Lake Darling with Canadian reservoirs (cfs)
March 15 to May 15	5,000*
May 16 to June 1	2,500
June 1 till pool is at 1596.0**	500

*Release may extend 5 to 10 days past May 15 for events approaching 100-year.

**The operating level may be increased to 1597 at FWS discretion. For purposes of analysis, the 1597 elevation is assumed.

B. Water Sharing Plan

Construction and operations of the large Canadian Dams will significantly decrease the water supply entering the United States. The legal U.S. share is half of the runoff which would have occurred in a state of nature (1959 Interim Measures). The actual runoff entering the U.S. is considerably more than the 50 percent share in most years, because Canada is unable to store and use their full share and because drainage projects have added large amounts of water. An extensive negotiation period with Saskatchewan representatives addressed the Canadians' request for a larger share of flows than provided by the Interim Measures. This resulted in the following proposals for water sharing.

Fish and Wildlife Service Proposal

1. This proposal is independent of the levels of Rafferty Reservoir and Alamdea Reservoir.

2. Except as hereinafter provided, Saskatchewan will pass 40 percent of the natural flow to North Dakota. Such lesser amount will be in recognition of Saskatchewan's agreement to operate both Rafferty Dam and Alameda Dam for flood control for the United States, and to account for increased evaporation as a result of such operation. This shall be deemed to be in compliance with treaty obligations and orders of the International Joint Commission.

3. If the level of Lake Darling is below an elevation of 1592.0 feet on October 1 in any year, Saskatchewan will then pass the remaining 10 percent of the natural flow in that year and 50 percent in succeeding years, until the level of Lake Darling is above elevation 1593.0 feet on October 1.

4. Under any of the foregoing conditions, North Dakota will assess its storage capability and needs prior to Saskatchewan releasing water to determine if a release is of benefit. If North Dakota will not benefit from the release, the water may be retained for use in Saskatchewan.

5. This proposal shall be considered as an interim measure until its implications can be fully assessed. Any changes to the terms of this agreement can be made only with the mutual consent of both parties.

Saskatchewan Proposal

1. Long Term: The proposal indicates that "except as hereinafter provided, Saskatchewan will pass 50 percent of the natural flow to North Dakota".

2. Exceptions: When Rafferty falls below 548 meters msl as of October 1st, any year, during the succeeding 12 months, Saskatchewan will only pass 40 percent of the natural flow. There are only 10 years in the simulation period which show an elevation of 548 or more on September 30th.

3. Lake Darling: If Lake Darling is below 1590 on October 1st, Saskatchewan will pass 50 percent of the natural flow until Lake Darling is above 1592. This occurs quite frequently. The 60/40 split occurs only 26 of the 62 years simulated. (This assessment is based upon interpolations between the Saskatchewan simulations of Treaty conditions and the 60/40 split.) The average difference in North Dakota's share between the Treaty and Alternate 2 is 5563 acre-feet.

4-5. These provisions are the same as in the FWS proposal.

For purposes of this analysis, adoption of the FWS proposal is assumed.

The obligation to provide a regulated flow of 20 cubic feet per second into Manitoba during the months of June to October inclusive (6,069 acre-feet), except in periods of severe drouth, will not be affected by the reduced water supply into the United States. The established drouth criteria, under which reduced flows to Manitoba are determined by the International Joint Commission, will not apply when low flows are the result of the water sharing agreement rather than natural conditions.

With the Canadian Dams, the proposed Flood Control Operating Plan and the FWS proposed Water Sharing Interim Measure.

This discussion centers on differences from the impacts reported for the 4-foot raise; i.e., low-flow effects, infrequent flood operations (>25-year event) below Lake Darling, and all operations above Lake Darling. For reasons enumerated previously in this report (without a plan condition), water supply effects of this project are considered to result from the difference between the existing condition and the FWS water sharing proposal, not from the difference between the Treaty provision (50/50 share at the Saskatchewan border) and the FWS water sharing proposal.

Aquatic Resources

Flood operations and low-flow operations will each affect the fishery in Lake Darling and downstream. Lake Darling is a principal source of fish recruitment for the river.

Flood operations will res ... extended durations of high, within channel discharges above Lake D... ing. Due to the nature of the channel in this reach, increased channel erosi... and sedimentation rates in upper Lake Darling are anticipated. This repre... nts a negative impact to the shallow lacustrine environment. The severit... depends on the frequency and magnitude of high-flow events. Habitats above L... e Darling will still be flooded, but not as high as

at present. Below Lake Darling, the aquatic resources should not be significantly affected except during years of infrequent events. Flushing or maximum flows will be maintained throughout the year into the winter. Canadian storage of flood flows should reduce the need for winter drawdowns at Lake Darling, thereby reducing the potential of fish winterkill resulting from this action.

Low flow operations represent a potentially severe threat to the sport fishery. Flows were simulated by Canada and the North Dakota State Water Commission for the historical period of 1912-1966, as if the proposed dams and agreements were in place. This simulation showed that Lake Darling would have fallen below 1592 elevation on October 1 in 43 of the 62 years (Table 2). Below this elevation, reservoir winterkill of the fishery becomes likely, based on past experience. A 62-year average of 4,902 acre-feet less of inflow than under the 50/50 treaty provisions would be received at the Sherwood Station. Records of late fall (November 30) elevations of Lake Darling, after the filling period, show that the elevation was below 1592.0 in 7 of 33 years. Under the project simulation for the same 33 years (Table 3) Lake Darling would have been below 1592.0 in 15 of the years (with Lake Darling conservation pool increased to 1597). The necessity of using Lake Darling to supply J. Clark Salyer NWR requirements not met by local inflows will require decisions that will jeopardize the Lake Darling fishery in favor of the higher priority waterfowl needs. Lake Darling will be frequently unable to store a 2-year water supply (61,000 acre-feet per year) for J. Clark Salyer NWR, as it now usually does. Lower operating levels could eliminate access to northern pike spawning areas. This could lower or eliminate the production of a given year class.

Water quality will be adversely affected by storage and uses in Canada. The principal impacts will result from reservoir effects, power plant cooling water discharges, and irrigation return flows. Nutrients, biocides, sediments and metals or other elements will accumulate in Lake Darling causing algae blooms, low oxygen conditions and potential toxic effects. The effects will be exacerbated during years of low water levels. The type of withdrawal facility to be installed in the Canadian Dams will greatly influence the discharge quality. Multi-level withdrawal capabilities are need to have some control over the quality of the releases. If oxygen deficiency and temperature changes are caused by reservoir releases, these effects should be substantially modified by the time the water reaches the U.S. Other changes may not be significantly altered by travel time.

Table 2

Simulation of Volume at Sherwood and Water Sharing Under
Saskatchewan and Fish and Wildlife Service Alternatives
Treaty = 50/50 Share

Year	Estimate of natural flow at Sherwood	Sask. Alt.	FWS Alt.	Sask. Volume	FWS Volume	Difference	Treaty - Sask. Alt.	Treaty - FWS Alt.
1912	81519	0.40	0.40	32608	32608	0	8152	8152
1913	52008	0.40	0.40	20803	20803	0	5201	5201
1914	59611	0.50	0.50	29806	29806	0	0	0
1915	3549	0.50	0.50	1775	1775	0	0	0
1916	136127	0.50	0.50	68064	68064	0	0	0
1917	86478	0.50	0.50	43239	43239	0	0	0
1918	34720	0.50	0.50	17360	17360	0	0	0
1919	75201	0.50	0.50	37511	37511	0	0	0
1920	117137	0.50	0.50	58569	58569	0	0	0
1921	22117	0.50	0.50	11059	11059	0	0	0
1922	90868	0.50	0.50	45434	45434	0	0	0
1923	118757	0.40	0.50	47503	59379	11876	11876	0
1924	42546	0.50	0.50	21273	21273	0	0	0
1925	159547	0.50	0.50	79774	79774	0	0	0
1926	28671	0.50	0.50	14336	14336	0	0	0
1927	246932	0.40	0.40	98773	98773	0	24693	24693
1928	150298	0.40	0.40	60119	60119	0	15030	15030
1929	31238	0.50	0.50	15619	15619	0	0	0
1930	39444	0.50	0.50	19722	19722	0	0	0
1931	2204	0.50	0.50	1102	1102	0	0	0
1932	6656	0.50	0.50	3328	3328	0	0	0
1933	56285	0.50	0.50	28143	28143	0	0	0
1934	19531	0.50	0.50	9766	9766	0	0	0
1935	9686	0.50	0.50	4843	4843	0	0	0
1936	46284	0.50	0.50	23142	23142	0	0	0
1937	2786	0.50	0.50	1393	1393	0	0	0
1938	38210	0.50	0.50	19105	19105	0	0	0
1939	73492	0.50	0.50	36746	36746	0	0	0
1940	5296	0.50	0.50	2648	2648	0	0	0
1941	40056	0.50	0.50	20028	20028	0	0	0
1942	72185	0.50	0.50	36093	36093	0	0	0
1943	205624	0.50	0.50	102812	102812	0	0	0
1944	48554	0.40	0.50	19422	24277	4855	4855	0
1945	11589	0.50	0.50	5795	5795	0	0	0
1946	62617	0.50	0.50	31309	31309	0	0	0
1947	150611	0.40	0.40	60244	60244	0	15061	15061
1948	251125	0.40	0.40	100450	100450	0	25113	25113
1949	64795	0.40	0.40	25918	25918	0	6480	6480
1950	91772	0.40	0.40	36709	36709	0	9177	9177
1951	177121	0.40	0.40	68448	68448	0	17112	17112
1952	57797	0.40	0.40	23119	23119	0	5780	5780
1953	168938	0.40	0.40	67575	67575	0	16894	16894
1954	76860	0.40	0.40	30744	30744	0	7686	7686
1955	241104	0.40	0.40	96442	96442	0	24110	24110
1956	183293	0.40	0.40	73317	73317	0	18329	18329
1957	43874	0.40	0.50	17550	21937	4387	4387	0
1958	48982	0.50	0.50	24491	24491	0	0	0
1959	27488	0.50	0.50	13744	13744	0	0	0
1960	125535	0.40	0.50	50214	62768	12554	12554	0
1961	7666	0.50	0.50	3833	3833	0	0	0
1962	17644	0.50	0.50	8822	8822	0	0	0
1963	42252	0.50	0.50	21126	21126	0	0	0
1964	49695	0.50	0.50	24848	24848	0	0	0
1965	89934	0.40	0.40	35974	35974	0	8993	8993
1966	63073	0.40	0.50	25229	31537	6307	6307	0
1967	42631	0.50	0.50	21316	21316	0	0	0
1968	21972	0.50	0.50	10986	10986	0	0	0
1969	287792	0.40	0.40	115117	115117	0	28779	28779
1970	178741	0.40	0.40	71496	71496	0	17874	17874
1971	87071	0.40	0.40	34828	34828	0	8707	8707
1972	173802	0.40	0.40	69521	69521	0	17380	17380
1973	16534	0.40	0.50	6614	8267	1653	1653	0
1974	282718	0.40	0.40	113087	113087	0	28272	28272
Ave.	84801	0.46	0.47	36838	37499	661	5563	4902

Table 3

Lake Darling Elevations (feet) With and Without Project
(Source: Canadian model with L. Darling conservation pool at 1597)

Year	Months Under 60/40	Elev. 50/50	Elev. 60/40	Difference	With Project	Historic
1942		1586.9	1586.9	0.0	1586.9	1593.0
1943	Dec.	1592.4	1589.4	3.0	1592.4	1593.1
1944	Jan.-Dec.	1593.5	1590.9	2.7	1590.9	1593.4
1945	Jan.-Sep.	1591.1	1587.8	3.3	1591.1	1589.0
1946		1590.5	1586.9	3.5	1590.5	1592.0
1947	Aug.-Dec.	1595.5	1592.4	3.1	1592.4	1592.6
1948	Jan.-Dec.	1596.3	1596.3	0.0	1596.3	1594.0
1949	Jan.-Dec.	1593.7	1593.7	0.0	1593.7	1593.7
1950	Jan.-Dec.	1596.3	1596.3	0.0	1596.3	1595.1
1951	Jan.-Sep.	1596.6	1596.6	0.0	1596.6	1594.7
1952	Oct.-Dec.	1594.6	1594.6	0.0	1594.6	1594.1
1953	Jan.-Sep.	1596.6	1596.6	0.0	1596.6	1596.3
1954		1597.0	1597.0	0.0	1597.0	1594.8
1955		1595.9	1595.9	0.0	1595.9	1593.6
1956		1595.0	1595.0	0.0	1595.0	1594.5
1957		1593.3	1593.2	0.1	1593.3	1592.6
1958		1588.2	1587.2	1.0	1588.2	1592.0
1959		1586.9	1586.9	0.1	1586.9	1588.8
1960		1590.2	1589.3	0.9	1590.2	1593.2
1961		1584.8	1584.2	0.7	1584.8	1588.1
1962		1586.0	1585.8	0.2	1586.0	1587.2
1963		1587.3	1587.0	0.3	1587.3	1588.8
1964		1587.9	1586.9	1.0	1587.9	1591.6
1965	Jun.-Dec.	1593.2	1592.6	0.6	1592.6	1594.9
1966	Jan.-Sep.	1591.8	1590.3	1.5	1591.8	1593.8
1967		1587.7	1586.9	0.7	1587.7	1592.1
1968		1585.8	1585.5	0.3	1585.8	1590.6
1969	Oct.-Dec.	1591.7	1591.3	0.4	1591.3	1595.1
1970	Jan.-Dec.	1596.6	1596.6	0.0	1596.6	1595.8
1971	Jan.-Dec.	1595.6	1595.6	0.0	1595.6	1594.9
1972	Jan.-Dec.	1596.7	1596.7	0.0	1596.7	1596.1
1973	Jan.-Dec.	1592.6	1592.6	0.0	1592.6	1594.3
1974	Jan.-Sep.	1595.2	1595.2	0.0	1595.2	1595.0

Terrestrial Resources

Reduced flooding of the riparian communities will result in decreased productivity and successional trends toward drier communities. At the same time, lower elevation wet meadows will be subject to infrequent prolonged inundations resulting from extended 500 cfs flood evacuation releases plus local inflows.

A reduction in the flood frequency will result in more clearing for residential development and agricultural uses along the river.

Wetland Resources

Flood water evacuation from the infrequent events will render J. Clark Salyer NWR inoperable from the standpoint of water management for the entire production season. Waterfowl production will be severely curtailed. Erosion of nesting islands near the channel will be increased. High flows after normal freezeup (about 15 November) will result in open water areas remaining. Delayed freezeup will cause waterfowl to remain in the area, rendering them subject to high mortality during the winter. The worst case would occur when waterfowl are attempting to winter and high flows stop, causing freezeup to occur in December, January or February.

Low flow operations will tend to have an opposite effect on downstream marshes. Reduction in or elimination of an operational water supply could make it difficult to maintain minimum water levels in the pools in J. Clark Salyer NWR. Low water levels could increase the spread of noxious weeds in the refuge. This could increase the operational cost to control those species. Reduced water levels would make the nesting islands vulnerable to predators. This could significantly reduce the waterfowl production of the Refuge. Repeated low annual discharges would have impacts on the operation, and habitat value of the Refuge. A reduction in the amount of water would accelerate the spread of cattail throughout the Refuge. An excessive spread of cattail would result in a loss of nesting, brood and post-breeding habitat. In addition, the spread of cattail would increase blackbird roosting sites. An increase in the blackbird population would increase the amount of crop depredation realized by adjacent landowners. A reduction in the flood frequency would encourage the implementation of wetland drainage projects that have been proposed, but not implemented due to the potential for accentuating flood problems.

J. Clark Salyer NWR has experienced botulism outbreaks in recent years that may be related to existing pollution sources during low flow periods. This problem may well be exacerbated by the reduced flows associated with the project combined with project-related declines in water quality. Low flows could cause a greater concentration of local inflows (drainage projects), with a higher load of contaminants entering the NWR.

DISCUSSION/MITIGATION/ENHANCEMENT

The operation and mitigation measures identified under "Description of the Project" for Upper Souris and J. Clark Salyer NWR's were included under the 4-foot raise project. They are also considered to be basic requirements for this project. This project would have less impact than the 4-foot raise project by eliminating habitat damages at Lake Darling from construction and inundation by the higher reservoir stages. The lesser impact will be partly offset by raising the conservation pool 1 foot. Although not quantified, the additional direct and indirect impact of this project, caused by greatly increased flood protection, prolonged evacuation of reservoirs after large floods, and by reduced water quality and quantity from the existing, or base condition, is considered to be potentially much larger than the reduction.

The Conceptual Operating Plan for Rafferty, Alameda, Boundary and Lake Darling Reservoirs for Flood Control (May 13, 1986) and the FWS water sharing proposal are assumed for purposes of this report. If significant changes are made in either or both of the plans, new evaluations and recommendations may be required. Even if the plans are not changed, there is potential for unforeseen or underestimated significant adverse effects of the project that may reduce the ability of the NWR's to fulfill their basic migratory bird and other objectives.

The National Wildlife Refuge Administration Act (16 USC 668 dd, as amended) requires the Secretary of the Interior to assess all proposed activities on National Wildlife Refuges to ensure that such activities are compatible with the purposes for which the refuge(s) was established. If such proposed activities are not compatible, the Secretary cannot allow them to occur. Activities or projects such as the Souris River Flood Control Project may be rendered compatible through complete mitigation of predicted and actual adverse impacts. Without such mitigation, the project cannot be permitted.

In order to ensure that the project is compatible and that the United States interests in the two Souris River Refuges are protected, it will be necessary to develop and implement a Memorandum of Agreement between the Service and the Corps of Engineers. Such a Memorandum of Agreement will allow the project to proceed while fulfilling the Service's obligation under the National Wildlife Refuge Administration Act as implemented by 50 CFR 29.

Additional measures should be considered for those years when the extra impacts occur. Preventing loss of the recreational fishery at Lake Darling and the water supply for J. Clark Salyer NWR and other downstream users should be top priority. The U.S. should negotiate provisions for emergency water supplies from Canadian reservoir releases as required by severe drouth, at times when it is needed and available, without regard to Treaty limitations or the new interim measures requirements. If water supplies are not provided and damages result from project operations, compensation for fish and recreational losses should be provided in accordance with American Fisheries Society monetary values of freshwater fish and fish kill counting guidelines (see Appendices A and B).

When infrequent floods require extended high flows past normal freezeup, hazing of waterfowl may be required. Emergency stabilization measures may be required on some facilities subject to prolonged erosion. The most practical way to deal with impacts of this nature is to establish an operation and maintenance fund to be used for management needs caused by project operations.

Other contingencies related to inadequate water supply or water quality contaminants, as discussed above, could require special actions such as vegetation control, disease control, and other direct habitat or population measures. At present, it is very difficult to anticipate potential impacts and to quantify those impacts. These difficulties lend support to the concept of a project operation and maintenance fund to support the public values of the two NWR's.

Multi-level withdrawal capabilities should be installed on both Rafferty and Alameda. A water quality study should be conducted based on land and water uses from the new Canadian storage and increased erosion and sedimentation above Lake Darling. This should be combined with a model of the Canadian reservoirs for stratification. Certain measures are possible at Lake Darling to offset these effects if the studies show the need. These measures would reduce the need for damages and contingency operations by reducing the probabilities of such events occurring. The measures include additional modifications to Lake Darling. The modifications could be performed at the same time as needed dam safety and outlet work. The structure could be modified to increase the conservation pool to 1598 to capture water when available to compensate for reduced flows. Additional outlet modifications to control the quality of releases from Lake Darling could offset impacts that may be caused by the quality of Canadian dam releases and irrigation return flows.

Regulations and/or incentives will be badly needed to protect the remaining wetland, woodland and grassland resources of the basin, under a high degree of flood protection. Both U.S. and Canadian interests should work together to coordinate resource protection measures. Zoning, greenbelts, discharge and drainage restrictions would be prime measures to consider for implementation.

RECOMMENDATIONS

1. The previously approved "Lake Darling Project" operation and mitigation measures, as described in this report under "Description of the Project" (page 4), be implemented as the base plan. The estimated cost is $7,722,000* (Design Memorandum 3, revised July 1985). Additions to the base plan be made sufficient to achieve full compensation of habitat losses due to flood operations. This would take the form of stabilization with riprap of nesting islands at J. Clark Salyer NWR. Some of the islands are subject to erosion from wave action caused by prolonged high discharges resulting from project flood control operations. The exact amount required has not been determined. A preliminary estimate for protection of 19 top priority islands is:

   14,000 cubic yards @ $30 = $420,000

   *Includes $416,000 FWS costs and $2,604,000 dam safety costs.

2. Multi-level water withdrawal capabilities be installed on Rafferty and Alameda Dams.

3. In order to complete the required compatibility determination (required by 50 CFR), additional studies be authorized and conducted to quantify effects of the project. The studies should include erosion and sedimentation, and other water quality changes including reservoir effects, and all uses and discharges associated with the dams. Water quantity data sufficiently refined for use as an operating model be developed. The relationships of the water quality and quantity changes to avian botulism and identification of mitigating measures should be included in the additional studies, and implementation of needed mitigating measures be authorized. Impacts associtaed with low flow conditions in particular need to be studied.

4. Additional measures that are found to be required to offset reduced flows and decreased water quality be authorized for implementation. They may include, but are not limited to, modifications of Lake Darling to increase the storage capability to 1598 elevation and to control the quality of releases from Lake Darling.

5. Negotiations be conducted with the international regulatory body to identify an additional framework of emergency water supply conditions for the U.S. and Manitoba. Measures to alleviate the conditions using releases from the Canadian dams when possible should be identified.

6. When and if project agreements or operations result in fishkills in Lake Darling, the Corps of Engineers will provide monetary compensation for fish and recreational losses. American Fishery Society monetary values of freshwater fish and fish kill counting guidelines (Appendices A & B) will be used to compute damages.

7. An operations, maintenance and replacement fund be established for the Fish and Wildlife Service. The fund would be used for management operations occasioned by project actions and agreements. OM&R measures would include but not be limited to waterfowl hazing, contaminant and disease control operations, vegetation control, and stabilization of Refuge facilities. The amount of such a fund and its operations will be determined during detailed studies.

8. Project sponsors and other involved interests will be actively encouraged by the Corps of Engineers to restrict wetland drainage and floodplain developments, and protect the riparian corridors in the Souris Watershed. The practice of releasing drainage waters into the Souris when flood peaks are subsiding, as an alternative to restricting new drainage, will be discouraged.

9. The low-flow water sharing agreement will be evaluated as an interim measure. If it results in unacceptable adverse effects to the migratory bird resource, this would violate the intent of the Migratory Bird Treaty. Appropriate changes should be made by mutual agreement. If this cannot be accomplished, the existing Treaty water sharing provision will be restored.

SUMMARY

This completes the FWS assessment of the Souris River project. This plan is only one phase of flood control and water management. Unless an effective way is found soon to restrict wetland drainage in both Canada and the U.S., the migratory bird and water quality problems will continue to increase and the wildlife and fishery resources will be further severely reduced.

Measures included in the "Recommendations" are considered necessary to achieve a plan that accounts for all public trust factors. In addition, continued project coordination will be required to deal with problems as they arise and avoid emergencies. Please notify us of any changes in project plans and contact us if you have any questions concerning this report. We also request that you inform us of actions taken on each of the recommendations.

Sincerely,

M. S. Zschomler

M. S. Zschomler
Field Supervisor, Fish & Wildlife Enhancement

Attachments

NORTH DAKOTA GAME & FISH DEPARTMENT

"Variety in Hunting and Fishing"

100 North Bismarck Expressway
Bismarck, North Dakota 58501 5095
Phone 701 221 6300

December 5, 1986

Mr. M.S. Zschomler
Field Supervisor
U.S. Fish & Wildlife Service
1500 Capitol Avenue
Bismarck, North Dakota 58501

RE: Coordination Act Report - Souris River Flood Control Project

Dear Mr. Zschomler:

We have reviewed the above referenced report and basically concur with the contents contained therein. Additionally, we request the following concern be included.

> The issue of water quality impacts on fishery resources is poorly quantified, if at all; and the issue of low flow regimes and adverse fishery impacts from same are not quantified. We insist as part of any authorization legislation a caveat be included which would mandate further studies on these issues and any adverse fishery impacts would be [illegible]ed to the degree they occur as an integral part of project authorization.
>
> The souris fishery is very important to Minot and surrounding areas, the assurance of protection of this valuable resource is critical to an acceptable project package.

Sincerely,

Dale L. Henegar
Commissioner

MM:DLH:ah

Appendix A

American Fisheries Society Special Publication No. 13, Monetary Values of Freshwater Fish and Fish-Kill Counting Guidelines, 1982

From Introduction to Part I, Monetary Values of Freshwater Fish

In 1970, the Pollution Committee of the Southern Division, American Fisheries Society, published "Monetary Values of Fish" in an effort to standardize fish values. This booklet was prepared primarily for use in the southeastern United States, but soon became accepted and used in many other areas of the country. The values were revised in 1975 to adjust for inflation. A similar booklet, "Reimbursement Values for Fish", was published in 1978 by the Monetary Values of Fish Committee of the North Central Division, American Fisheries Society.

The growing acceptance of both publications raised the concern that several lists might detract from the effectiveness of any one of them. This prompted formation of a Society-wide committee to determine the feasibility of a single publication listing the monetary values of freshwater fish in the United States. This committee (Sam Spencer, Alambama; James Adams, California: Allen Elser, Montana: Donald Duerre, North Dakota: David Mayhew, Pennsylvania: Hudson Nichols, Chairman, Tennessee) unanimously recommended that such a document be developed. This recommendation was approved by the Executive Committee of the American Fisheries Society in August 1978, and the present committee was appointed by President Henry Regier to implement it. The committee was reappointed by President Richard Stroud in 1979 to complete the task. The product is a set of documented monetary values of freshwater fish that may be used, in conjunction with standard sampling programs outlined in Part II of this book, to assess the value of fish destroyed in fish kills. These values also can be used in fishery mitigation efforts, preparation of environmental impact statements, and evalutions of competitive water uses.

The monetary-values concept presented here is based on the premises that:

1. fish are resources, and have tangible values to the public and the aquatic ecosystems;

2. when fish are destroyed and blame can be documented, compensation to the public agency responsible for management is required;

3. hatchery production costs provide the most reasonable source of fish value information.

The concept has been widely used and upheld in three court cases (page 21).

Monetary values presented here were derived from comprehensive surveys of commerical fish producers in 1979-1980 (see pages 22-26). That survey did not produce information for all species. In some cases, values assigned to a particular species are equal to those of similar species covered by the 1979-1980 survey. In other cases, fish values are based on the 1975 Southern Division and the 1977 North Central Division surveys. For some species not

cultured, commercial values of harvested fish are employed. Values for species not included on pages 5-20 should be determined by the best judgement of fishery experts from available values of closely related species.

Threatened and Endangered Fish listed in the United States "Federal Register" (January 17, 1979) are not included because they are protected by federal statutes. Many rare fish not federally protected, but protected by individual states, are included. The values assigned these rare species do not reflect their uniqueness, and if they are killed there should be prompt action beyond initial monetary assessment.

Whenever a fish kill occurs in a valuable recreational or commercial fishery, the real losses are greater than just the monetary value of the fish. If such a kill results from human activity, every effort should be made to seek additional damages in such cases. For example, if financial costs of lost angler-days or long-term losses to commercial fishery can be estimated, these should be included in the total assessment.

The committee also recommends that assessment of damages resulting froma fish kill include not only the value of the fish, but also the cost of the investigation: salaries and per diem of investigators; transportation and fuel; special equipment; etc.

Appendix B

American Fisheries Society Special Publication No. 13,
Monetary Values of Freshwater Fish and Fish-Kill Counting Guidelines, 1982.

From Introduction to Part II, Fish-Kill Counting Guidelines

The objective of a fish-kill investigation is not only to determine the number of dead fish, but also to estimate their size distributions and, in some cases, weights so that values of the fish lost can be calculated. In most states or provinces, the primary responsibility of fishery biologists in this context is to delineate the kill by species and magnitude. Exact identification of the toxicant usually is delegated to a pollution-control agency.

Fish kills typically are unexpected and short-lived. They give little time to design a sampling program that can be defended scientifically and statisically. It is important, therefore, to have standard procedures available for estimating the size of fish kills. Recognizing this, the Pollution Committee published sampling guidelines in 1970 and in 1979: this account follows the 1979 draft closely. It describes methods for narrow streams and for wider streams (including meandering streams) and lakes. It does not cover the use of aerial photography or special methods appropriate in tidal estuaries. The methods can be carried out with either English or metric units; this dicussion generally follows the English system of measurement.

These sampling procedures are designed for a one-time pickup. The resulting estimates will be conservative; very seldom will they represent more than a modest fraction of the fish killed because they will be based only on fish actually seen at one point in time. Most fish kills do not occur instantaneously. Fish die at differing rates, and once dead they may float or sink on different schedules; for the same species and toxicant these rates vary with water quality and temperature. A one-time count will miss many dead fish because they lie too deep in the water to be seen, are hidden by debris, have been taken by scavengers, have decomposed, or are visible but overlooked (human error). Live fish that may yet die will not be included. When these guidelines were tested during and experimental 3-day rotenone kill in Barkley Lake, Kentucky, estimates of total dead fish made early the second morning were only about half of the fish picked up during that entire day and about 40 percent of those picked up during 3 days. Although the methods underestimate the true damage, few agencies can afford more extensive fish-kill investigations.

The best way to determine the number of available dead fish is to collect them all, and this should be done whenever practical. Often, however, it is impossible to make a complete collection because of the great numbers killed and the large area over which they are scattered. Therefore, partial or sampling assessments must be made. A potential weakness of partial counts is that bias may be introduced. To produce unbiased results certain simple principles of area sampling must be followed:

1. Sampling units are areas. Where dead fish are scattered over an extended area (stream, lake shore, or open water), their numbers may be estimated by expanding collections and counts from sample areas to the entire affected area. That is, areas, not fish, are sampled.

2. Sampling units must be chosen at random. To avoid the action of personal bias, either intentional or unintentional, the sample areas must be chosen by a completely objectives method that, in principle, allows any possible sample area to be selected for counting. Although selection of sample areas by "judgement" may seem to give more "representative" samples, such selection destroys the objectivity of the sampling and makes the results completely vulnerable to an accusation of bias. The more likely the results are to be exposed to hostile criticism, the more mandatory it is that the sampling be at random and, therefore, as defensible as possible. If deviation from strictly random sampling cannot be avoided, then every effort must be made to maintain objectivity in sampling. Methods described here use systematic samples for field practicality and simplicity, with a random start to avoid bias.

3. Precision depends on sample size and number of fish counted. The larger the sample size (number of sample areas counted) and the greater the number of dead fish counted, the more reliable will be the estimate of the total number killed.

The statistical reliability, or precision, of the estimated numbers of dead fish is determined by the variability of the counts and the number of sample areas counted. There is little that can be done about the variability, except that a prudent application of stratified random sampling can help (see page 36). The sample size, however, is under the control of the investigator, within budgetary limits. Precision may be expressed as proportional standard error of an estimate (page 37).

Counts of dead fish may be extremely variable, and the sample size required for a precision ordinarily considered scientifically respectable may be prohibitively expensive. This is especially true when size-class abundance is estimated for uncommon species. Thus, good precision for the estimates means a high cost to the investigating agency and, when these costs are passed along to the party that caused the kill. The appropraite balance between cost and precision will vary with the circumstances. When the purpose of counting is to determine monetary values of the fish killed, it makes good sense to concentrate on making the estimates unbiased, and to be satisfied with modest precision for the overall estimates and with poor precision for categories of rare items. As a practical approach, a minimum of three rather large samples is suggested at several points in this discussion. This sample size will not provide good precision, and may not be adequate for many needs.

No guidelines are feasible for every set of field conditions. Biologist investigating fish kills who may be forced to deviate from the methods described here should follow the principles of area sampling as closely as possible. Deviations and reasons for making them should be described in the field notes for later reference.

COE Responses to FWS Recommendations

FWS Recommendation 1 - The previously approved "Lake Darling Project" operation and mitigation measures, as described in the Fish and Wildlife Coordination Act report under "Description of the Project" (page 4), be implemented as the base plan. The estimated cost is $7,722,000* (Design Memorandum 3, revised July 1985). Additions to the base plan be made sufficient to achieve full compensation of habitat losses due to flood operations. This would take the form of stabilization with riprap of nesting at J. Clark Saler NWR. Some of the islands are subject to erosion from wave action caused by prolonged high discharges resulting from project flood control operations. The exact amount required has not been determined. A preliminary estimate for protection of 19 top priority island is:

14,000 cubic yards @ $30 = $420,000

*Includes $416,000 FWS costs and $2,604,000 dam safety costs.

COE Response - The proposed migitation plan provides 89 percent compensation for all quantifiable impacts. The proposed plan differs from the FWS recommendation in that it does not include riprapping of nesting islands or construction of pothole wetlands. Given updated cost estimates, these two features do not appear to be incrementally justified (see appendix 4) and were therefore dropped from the proposed plan.

FWS Recommendation 2 - Multi-level water withdrawal capabilities be installed on Rafferty and Alameda Dams.

COE Response - If the Canadian dams result in water quality degradation in the U.S., they would do so irregardless of the proposed flood storage plan. For this reason, potential water quality impacts which might be alleviated by multi-level outlets are not attributable to the proposed action. Although the COE would support the use of multi-level outlets on the dams, there is no authority to require Saskatchewan to install such outlets.

FWS Recommendation 3a - In order to complete the required compatibility determination (required by 50 CFR), additional studies be authorized and conducted to quantify effects of the project. The studies should include erosion and sedimentation, and other water quality changes including reservoir effects, and all uses and discharges associated with the dams.

COE Response - The Corps does not believe that the proposed action would result in any significant change in erosion/sedimentation rates (see paragraph 5.39 in the EIS), and therefore is not planning any further study of erosion/sedimentation changes. Canadian water resource development and/or general basin development could adversely affect water quality in the Souris River in Canada and the U.S. similar to the impacts of developments that have occurred in the past in the U.S. portion of the basin. Water quality monitoring conducted by the North Dakota Department of Health, the U.S. Geological Survey and related agencies appears to be

adequate to reasonably assess water quality changes due to reservoirs, uses and discharges associated with the dams.

FWS Recommendation 3b - Water quality data be developed at a level sufficiently refined for use as an operating model.

COE Response - Water quality models for flood and nonflood events appear to be adequate. Existing water quantity models developed by the North Dakota State Water Commission and Saskatchewan Water Corporation provide monitoring data which is used by the International Board of Control to assess the apportionment of water between Saskatchewan and North Dakota. The Corps of Engineers hydrologic model provides for the analysis of flood runoff. These models are the state of the art and provide the basis for decisions related to the proposed action. Development of additional models does not appear warranted.

FWS Recommendation 3c - The relationships of the water quality changes to avian botulism and identification of mitigating measures should be included in the additional studies, and implementation of needed mitigating measures be authorized. Impacts associated with low flow conditions in particular need to be studied.

COE Response - No studies of the relationship between botulism problems and water quality/quantity changes are proposed because most of the impacts would not be attributable to the proposed action and there is a high degree of uncertainty in the relationship between bolutism, water quality, and water quantity. Impacts under low and moderate flow conditions were determined using the best available hydrologic studies.

FWS Recommendation 4 - Additional measures that are found to be required to offset reduced flows and decreased water quality be authorized for implementation. They may include, but are not limited to, modifications of Lake Darling to increase the storage capability to 1598 elevation and to control the quality of releases from Lake Darling.

COE Response - The effects of reduced flows result almost entirely from retention of 50% of runoff in Saskatchewan which will occur with or without the project. Since these effects would not result from the proposed action, no further studies or mitigation measures are recommended.

FWS Recommendation 5 - Negotiations be conducted the international regulatory body to identify an additional framework of emergency water supply conditions for the U.S. and Manitoba. Measures to alleviate the conditions using release from the Canadian dams when possible should be identified.

COE Responses - The impacts of drought and the identification of emergency water supply conditions and plans can not be attributable to this flood control project. The District believes that an updated drought contingency plan is important to the Souris Basin and the storages available in Rafferty and Alameda reservoirs provide new opportunities for water

management in the U.S. and Canada. The District would be willing to participate in studies and provide technical assistance to facilitate such a plan.

FWS Recommendation 6 - When and if project agreements or operations result in fishkills in Lake Darling, the Corps of Engineeres will provide monetary compensation for fish and recreational losses. American Fishery Society monetary values of freshwater fish and fish kill counting guidelines (Appendices A & B) will be used to compute damages.

COE Response - The proposed project should not significantly affect the frequency or severity of fishkills in Lake Darling when compared to the future without-project conditions. For this reason the proposed project does not include any mechanism for making the recommended payments.

FWS Recommendation 7 - An operations, maintenance and replacement fund be established for the Fish and Wildlife Service. The fund would be used for management operations occasioned by project actions and agreements. OM&R measures would include but not be limited to waterfowl hazing, contaminant and disease control operations, vegetation control, and stabilization of Refuge facilities. The amount of such a fund and its operations will be determined during detailed studies.

COE Response - The proposed mitigation plan provides adequate compensation for all identified project impacts. Most of the impacts referenced in this recommendation will occur without the project, and the proposed project would not significantly affect these problems.

FWS Recommendation 8 - Project sponsors and other involved interests will be actively encouraged by the Corps of Engineers to restrict wetland drainage and floodplain developments, and protect the riparian corridors in the Souris Watershed. The practice of releasing drainage waters into the Souris when flood peaks are subsiding, as an alternative to restricting new drainage, will be discouraged.

COE Response - Although the COE has no authority to restrict wetland drainage in the Souris Basin, we do support drainage control efforts by others to the maximum extent possible.

FWS Recommendation 9 - The low-flow water sharing agreement will be evaluated as an interim measure. If it results in unacceptable adverse effects to the migratory bird resource, this would violate the intent of the Migratory Bird Treaty. Appropriate changes should be made by mutual agreement. If this cannot be accomplishment, the existing Treat water sharing provision will be restored.

COE Response - The evaporation agreement is being proposed as an interim agreement in that it could be changed any time provided there is mutual consent of all parties involved. In the absence of mutual consent, the proposed evaporation agreement would remain in effect. This provision is part of the joint agreement reached in negotiation sessions involving

representatives of U.S. interests (including FWS) and the Province of Saskatchewan.

APPENDIX 2

Letters Received During the Scoping Process

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
ONE DENVER PLACE — 999 18TH STREET — SUITE 1300
DENVER, COLORADO 80202-2413

JUN 13 1986

Ref: 8PM-EA

Gary Palesh
Environmental Resources Branch
Planning Division
St. Paul District
Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Mr. Palesh:

We would like to thank you for the opportunity to provide scoping comments for the Souris River Project at this time. Dave Ruiter and Wes Wilson, of my staff, have informed me of their June 3, 1986 discussions with you and your staff concerning your efforts to prepare a draft EIS prior to 1987.

The major concern we have with the project description is the baseline hydrologic conditions to be included in the DEIS. The past Souris River impact assessments have addressed the environmental conditions based on the historic and current flow regime. We now understand that this "baseline" condition will be changed to reflect the assumption that Saskatchewan will soon fully develop its water rights as provided for as interim measures by the International Joint Commission in 1958. We feel that a change in "baseline" conditions at this time would be confusing since this flow reduction has yet to occur. In an effort to reduce the confusion to a minimum, and to provide the disclosure required under the National Environmental Policy Act, we recommend, at a minimum, the following set of alternatives be thoroughly assessed in the draft EIS.

1) No Federal Action: This alternative should document the environmental effects associated with the construction and operation of the Canadian Reservoirs as water supply reservoirs. While we recognize that the Corps is not responsible for the impacts associated with the implementation of the Saskatchewan water rights, it will be necessary to understand the impacts of the Canadian water rights on the Souris River system in order to understand the changes attributable only to the proposed flood control project. This alternative should include a thorough discussion of the changes in wet, average and dry year discharge conditions.

2) Four-foot raise of Lake Darling Dam (25 years of Flood Protection): This alternative should document the impacts associated with the combination of the reduction in Souris River discharge connected with the development of the Saskatchewan water rights and the four-foot raise in Lake Darling.

3) Purchase of flood protection in Canadian Reservoirs (Flood protection for 100-year flood event): This alternative analysis should document the impacts associated with the combination of the reduction in Souris River discharge connected with the development of the Saskatchewan water rights and the purchase of storage and operational changes in the Canadian Reservoirs to provide Souris River flood protection.

The use of the above alternative analysis to address the significant issues outlined in the scoping announcement (along with any additional issues developed during the public comment period) will assist in developing an adequate NEPA analysis. The draft EIS should thoroughly document the reasons for elimination of alternatives such as flow easements. We also recommend you thoroughly document the available mitigation options in the Draft EIS and incorporate as many as possible into the project design.

If we can be of further assistance in the scoping and alternative selection process at this time, please contact myself or Dave Ruiter of my staff (FTS 564-1702).

Sincerely,

Dale Vodehnal

Dale Vodehnal, Chief
Environmental Assessment Branch

cc: M.S. Zschomler, USFWS, Bismark
Milt Lindbig, Water Commission, ND
Francis Schwindt, Health Department, ND

United States Department of the Interior
FISH AND WILDLIFE SERVICE
1500 CAPITOL AVENUE
BISMARCK, NORTH DAKOTA 58501

JUN - 3 1986

Mr. Gary Palesh, Chief
Environmental Analysis Section
Environmental Resources Branch, Planning Division
1135 U.S. Post Office and Customs House
St. Paul, Minnesota 55101-1479

Re: Draft Scope for the Supplement to Lake Darling Environmental Impact Statement, Souris River, North Dakota

Dear Mr. Palesh:

This responds to your notice of intent of May 8, 1986, for the subject EIS. The Service is designated as a cooperating agency in the notice by virtue of jurisdiction by law, including Service participation in the support agreement and Scope of Work for Fiscal Year 1986. Under separate cover, we are providing the information called for in the Scope of Work, which includes significant issues to be addressed in your EIS. However in order to emphasize the Service's major concerns, we will further address them here.

1. The existing condition against which project impacts will be measured must include the flows presently accruing to the U.S., to which Canada is legally entitled under a 1959 interim agreement but is unable to utilize without the dams in place. Utilization of the flows by Canada constitutes what is probably the most signicant impact to the migratory waterfowl resource and operation of the internationally important Souris Loop Refuges. Since construction of the dams is contingent upon U.S. purchase of flood storage, utilization of Canada's flows is also contingent upon the purchase of flood storage and is, therefore, a project impact and should be addressed as such. If water supply is not addressed as an impact in the EIS, the opportunity to negotiate with Canada for ways to alleviate potential shortages through a banking system will be severely curtailed. If the NWR's are unable to function as intended because of loss of water after Canada has been paid for flood control, the U.S. will be forced to negotiate for acquiring water and make additional payments to Canada, with no assurance that either water or funds will be available.

2. The authorized purposes of wildlife and water conservation for Lake Darling will not be changed by the proposed flood control project. Operations to minimize flood damages downstream will be conducted when necessary. The frequency of such operations is anticipated to be much less than under existing conditions or with the proposed 4-foot raise.

3. Habitat evaluation conducted for the 4-foot raise project did not include a new conceptual operating plan for maximum releases from Lake Darling in conjunction with the operation of the Canadian Reservoirs in excess of the 25-year event. This conceptual operating plan would be expected to have greater impact to fish and wildlife resources then the project's impacts analyzed for the 4-foot raise. Therefore, less damaging alternatives to this operating plan should be considered. The Service has emphasized throughout that the preferred flood operating plan to minimize overall impacts is to discharge flood storage flows as early as possible rather than prolonging high flows through the summer, fall and winter.

4. Other impacts due to reservoir construction and operation in Canada should also be addressed in addition to flood control operations and water supply. The principal ones are changes in water quality and the overall function of the Souris Refuges. A river system hydrological modeling effort is suggested in order to adequately describe and provide for optimized total year around water operations and to develop the best possible system to minimize impacts and accommodate all concerns.

5. Since the project has changed significantly from the Lake Darling site specific EIS, consultation regarding federally endangered and threatened species should be reinitiated with the Grand Island, Nebraska Endangered Species Office.

Sincerely,

M.S. Zschomler

M.S. Zschomler
Field Supervisor, Habitat Resources

JONATHAN C. EATON
506 Midwest Federal Savings Bank Bldg.
MINOT, NORTH DAKOTA 58701

May 13, 1986

Joseph Briggs
Colonel, Corps of Engineers
Department of the Army
1133 U.S. Post Office & Custom House
St. Paul, MN 55101-1479

Dear Colonel Briggs:

I received your letter of May 8th addressed to people interested in the Souris River Flood Project.

I am a landowner within the Eaton Flood Project in McHenry County and I noted the absence of the Eaton Flood Project as one of the "significant issues" that the supplemental EIS will deal with.

Under its ancient water rights the Eaton Flood Project has relied on water in the Mouse River since approximately 1936 and its right to continue to receive that water from Lake Darling or dams above it should be the subject of any EIS supplement

I suggest that in addition to myself you should reply to Melvin Nelson of rural Towner ND 58788 chairman of the flood board, and its secretary. Attorney Michael McIntee, also of Towner

Yours truly,

Jonathan C. Eaton

JCE:lp

cc: Melvin Nelson
Michael McIntee

Working for the Nature of Tomorrow

NATIONAL WILDLIFE FEDERATION

1412 Sixteenth Street, N.W., Washington, D.C. 20036-2266 202 797-6800

June 17, 1986

Mr. Gary Palesh, Chief
Environmental Analysis Branch, Planning Division
U.S. Army Corps of Engineers
1135 U.S. Post Office and Customs House
St. Paul, Minnesota 55101-1479

Dear Mr. Palesh:

The National Wildlife Federation is pleased to comment on the scoping process for the Supplemental Environmental Impact Statement (SEIS) for the proposed Lake Darling Flood Control Project, Souris River, North Dakota. We are the nation's largest conservation organization with over 4.5 million members and supporters nationwide, including 51 State and Territorial Affiliates. We also have strong ties with the Canadian Wildlife Federation.

The Corps of Engineers and the State of North Dakota are considering paying part of the costs of two new dams in the Province of Saskatchewan, the Rafferty and the Alameda, that would provide greater reduction in flood damages along the Souris River in North Dakota at a lower cost to American taxpayers than would the raising of Lake Darling Dam. The Notice of Intent to prepare a supplemental environmental impact statement proposes to address impacts *solely in the United States* resulting from the construction and operation of the Canadian dams that were not addressed in previous EISes for the currently authorized four-foot raise of Lake Darling Dam. The Lake Darling Dam is operated by the U.S. Fish and Wildlife Service primarily for the benefit of the Upper Souris and J. Clark Salyer National Wildlife Refuges.

The major purpose of the Rafferty Dam would be to provide cooling water for a coal-fired electric generating plant that might be built by Saskatchewan Power. The reservoir would be managed to reduce downstream flooding in North Dakota, an incidental benefit. Proponents claim that the dam may also provide recreation

and irrigation benefits. Even if these benefits accrue, their present value would be small because it could take up to 12 years for the reservoir to fill.

The scope of the proposed SEIS is too narrow. **The National Wildlife Federation urges that the study encompass economic and environmental impacts within the entire Souris River Basin. In addition, it should formulate and evaluate all reasonable alternatives to reduce flooding and provide cooling water for the proposed power plant.** The new Canadian dams, in conjunction with the operation of the existing Boundary Dam in Saskatchewan and the existing Lake Darling Dam in North Dakota, may not be the best solution to the perceived problems.

The comprehensive SEIS should be coordinated closely with Canadian studies. Sec. 102(E) of the National Environmental Policy Act directs all agencies of the Federal Government to "recognize the worldwide and long-range character of environmental problems and, where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment."

The Rafferty and Alameda Dams in Saskatchewan would inundate valuable bottomlands, encourage drainage of wetland habitat, halt fish migrations, and reduce downstream flows during filling of the reservoirs. The estimated economic benefits and costs of the projects should be reexamined to incorporate lowered prices of electric power and agricultural crops.

One of the alternatives to Rafferty Dam would be to install an air-cooling system at the proposed generating plant. Another alternative would be to purchase low-cost electric power from power-surplus Manitoba Hydro instead of building a new plant. The United States could compensate Saskatchewan interests to time releases from the existing Boundary Dam to reduce downstream flooding.

We also suggest that the additional features included in the Lake Darling authorization, such as levee improvements, be reconsidered as part of the supplemental study. The original authorization would have provided 25-year flood protection at Minot. The Rafferty-Alameda plan would provide up to 100-year protection and therefore the planned additional features would provide few incremental benefits.

The U.S. Water Resources Council's Principles and Guidelines for Water Resources Studies (P&G) state in Principle 4 that, "Federal water resources planning is to take into account international implications, including treaty obligations." The Principle of the P&G and the Boundary Waters Treaty Act of 1909 apply to actions affecting rivers, such as the Souris, that flow within both the United States and Canada.

Failure to incorporate the effects of biota transfer to the Hudson Bay Drainage in the early plan documents of the Bureau of Reclamation's Garrison Diversion Unit in North Dakota created a controversy with Canada that resulted in lengthy delays for the project. The Garrison Diversion was originally authorized as the Missouri-Souris Unit in 1944 and now, in 1986, is only partially built.

Another example of the consequences of ignoring transboundary impacts is the Welton-Mohawk Irrigation Project in Arizona that substantially increased the salinity of the Colorado River before it entered Mexico. The United States has incurred substantial costs in building the Yuma desalinization plant to mitigate for the irrigation project. (See Oyarzabal-Tamargo & Young "International External Diseconomies: The Colorado River Salinity Problem in Mexico" 18 Natural Resources Journal pp. 77-89, 1978.) Professor Charles Howe wrote:

> [I]gnoring impacts on other nations has proved to be shortsighted and can result in later, costly attempts to ameliorate the international impacts. The resulting damages to Mexican agriculture (from the Welton-Mohawk)

were not counted in the benefit-cost analysis of the project and the political repercussions were so strong that Presidents Nixon and Echevarria met to negotiate a solution, one that turned out to be extremely costly and inefficient. ("Colorado-Big Thompson Project," 26 Natural Resources Journal, pp. 77-93,1986.)

Project impacts that flow across political boundaries have often been ignored in narrowly-defined studies. The *boundary* should be ignored during the preparation of the SEIS. We urge that the environmental and economic impacts of all reasonable alternative plans be evaluated during the study of this innovative proposal to solve problems of both nations cooperatively.

Thank you for your consideration of these views.

Sincerely,

E. R. Osann

for David C. Campbell
Resources Economist
Water Resources Program

cc: Duane Anderson, President
North Dakota Wildlife Federation
Loren Scott, President
Saskatchewan Wildlife Federation
Pamela Deacon
Embassy of Canada

NORTH DAKOTA
STATE DEPARTMENT OF HEALTH
State Capitol
Bismarck, North Dakota 58505

ENVIRONMENTAL HEALTH SECTION

1200 Missouri Avenue
Box 5520
Bismarck, North Dakota 58502-5520

June 13, 1986

Colonel Joseph Briggs
Corps of Engineers
St. Paul District
1135 U.S. Post Office
and Custom House
St. Paul, MN 55101-1479

Dear Colonel Briggs:

Thank you for giving this Department the opportunity to be involved in the scoping process for the supplement to the Lake Darling environmental impact statements for flood control on the Souris River.

The primary emphasis of our review of the environmental impact statement will focus on water quality and subsequent impacts on indigenous biota. Therefore, the following information should be included in the statement which will provide this Department with an adequate data base upon which to base decisions:

1. Provide quantification of major cation/ion constituents of total dissolved solids.

2. Provide quantification of nutrient concentrations including nitrate, ammonia, total phosphorus, and dissolved orthophosphorus.

3. Determine impacts on major trophic levels at realistic concentrations as determined above.

4. Develop an operating plan that incorporates North Dakota water quality criteria.

If you have any questions, please feel free to contact me.

Sincerely,

Michael T. Sauer

Michael T. Sauer
Limnologist
Water Supply & Pollution Control

MTS:krh

United States
Department of
Agriculture

Soil
Conservation
Service

P. O. Box 1458
Bismarck, ND
58502-1458

June 2,1986

Gary Palesh
Corps of Engineers, DOA
Env. Resources Branch Plan. Div.
1135 U. S. P. O. and Custom House
St. Paul, MN 55101-1479

Dear Mr. Palesh:

The Soil conservation Service has reviewed the proposed scope for the Souris River flood control project supplement to the Lake Darling EIS dated May 8, 1986. We have no comments to offer at this time; however, we appreciate the opportunity to do so.

Sincerely,

Charles E. Mumm ACTING
AUGUST J. DORNBUSCH, JR.
State Conservationist

Correspondence Regarding
Cultural Resources

State Historical Society
of North Dakota (State Historical Board)
North Dakota Heritage Center, Bismarck ND 58505
Telephone 701-224-2666

IN RESPONSE PLEASE REFERENCE: 82-11(8)2.3

May 29, 1986

Gary Palesn
Environmental Resources Branch
Planning Division - COE
1135 U S Post Office & Custom House
St Paul, MN 55101-1479

RE: Scoping for International Flood Control EIS; Souris River.

Dear Mr. Palesh:

We concur with the Draft Scope for the Supplement to the Lake Darling EISes that the effects of the proposed project on cultural resources is a significant issue which should be addressed. To the extent that prehistoric peoples did not recognize modern international boundaries, and that much of North Dakota's prehistory was directly related to sites, peoples and activities for which archeological evidence lies in what is now Canada, we believe the Corps should also consider the effects of its proposed plan on those resources. While we are not sure about the mechanics of application of the National Historic Preservation Act of 1966, as amended (NHPA), and/or the regulations at 36 CFR, Part 800, to significant cultural resources outside the United States, in our opinion the proposed action may effect such resources in Saskatchewan. Further, those effects may be adverse if sites integral to our understanding of Northern Plains and North Dakota prehistory are destroyed without appropriate identification, evaluation and preservation efforts.

We will be glad to work with the Corps of Engineers toward successful completion of the EIS and compliance with the NHPA. Thank you for providing us the opportunity to comment on this undertaking. If you have any questions regarding these comments, please feel free to contact Mr. C. L. Dill of our staff at (701)224-2672, or in writing.

Sincerely,

James E. Sperry
State Historic Preservation Officer
(North Dakota)

CLD/je
cc: Scherfy - MTSHPO
Saskatchewan Provincial Archeologist
ACHP - Golden

Berwick/sg/7854
File: Berwick-1;Souris

June 25, 1986

Environmental Resources
Planning Division

Mr. James E. Sperry
State Historical Society
of North Dakota
North Dakota Heritage Center
Bismarck, North Dakota 58505

Dear Mr. Sperry:

This responds to your letter of May 28, 1986 expressing concerns that the Corps flood control study of the Souris River basin address the effects of construction of the project on cultural resources in Canada. We appreciate your concerns about the potential loss of the Northern Great Plains archeological data base, and we assure you that all appropriate measures are being taken to record and preserve the cultural sites of this area.

Archeological field work on Rafferty Reservoir was initiated in 1984 with an intensive survey of the damsite, the spillway, and the area of the power plant. In addition, a sample survey of the reservoir area was made. This work will be incorporated into the EIS (Canadian) which is not yet completed. Work at Rafferty Dam has focused on the dam, spillway, and power plant because of a scheduled construction start of fiscal year 1987. Field work at Rafferty and Alameda Dams will continue over the next several field seasons. While no archeological field work has been conducted at Alameda Dam as yet, a reconnaissance survey is planned for this field season.

Cultural resources work being conducted in Saskatchewan will not come under the purview of the National Historic Preservation Act or other Federal laws and regulations of the United States government. Archeological survey, assessment, and mitigation of significant resources will be conducted under the authority of the Heritage Resources legislation of Saskatchewan. Archeological work directly associated with the flood control features of Alameda and Rafferty Dams will be conducted by the Canadians under their legislation but will be paid for with funds transferred to them by the United States.

We hope that this letter has addressed your concerns. Should you have any questions about the flood control project, please contact Mr. David Berwick of my staff at (612) 725-7854. For copies of the EIS and questions concerning the Canadian portion of the project, you may contact Mr. Ray Kenny, Environmental Programs, Saskatchewan Power Corporation, 2025 Victoria Avenue, Regina, Saskatchewan S4P0S1. Mr. Kenny can be reached at (306) 566-2851.

Sincerely,

Louis Kowalski
Chief, Planning Division

Identical letters sent to:

Mr. Ray Kenny
Environmental Programs
Saskatchewan Power Corporation
2025 Victoria Avenue
Regina, Saskatchewan S4P0S1

Mr. Brian Spurling
Saskatchewan Provincial Archeologist
Saskatchewan Culture and Recreation
1942 Hamilton Street
Regina, Saskatchewan S4P3V7

KRUCHTEN PD-RC
BERWICK PD-ER
KNOTT PD-ER
KOWALSKI PD

State Historical Society
of North Dakota (State Historical Board)
North Dakota Heritage Center, Bismarck ND 58505
Telephone 701-224-2666

IN RESPONSE PLEASE REFERENCE: 82-11(8)2.3

July 16, 1986

Brit Storey
Advisory Council on Historic Preservation
Western Division of Project Review
730 Simms Street, Room 450
Golden, CO 80401

RE: Souris River Basin Flood Control.

Dear Mr. Storey:

On May 28, 1986 we recommended to the Corps of Engineers (COE) that significant cultural resources to be affected in Canada should be considered in COE's planning for the above referenced project. Their response (copy enclosed) indicates that while these matters will be handled through the transfer of funds to appropriate Canadian authorities, the National Historic Preservation Act of 1966, as amended (NHPA), is not applicable.

We continue to be concerned that significant cultural resources are properly treated, and that data necessary to understand and interpret Northern Plains prehistoric and historic cultural resources are exchanged between those of us who bear responsibility for such resources. Any advise the Council can provide about the applicability of the NHPA, or about coordination of data, research designs and treatment plans will be greatly appreciated.

Sincerely,

C. L. Dill
Review & Compliance Coordinator

CLD/je
cc: Berwick, COE
Spurling, Saskatchewan Prov. Arch.

82-11(8)2.3

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
1135 U.S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101-1479

REPLY TO
ATTENTION OF

June 25, 1986

Environmental Resources
Planning Division

Mr. James E. Sperry
State Historical Society
of North Dakota
North Dakota Heritage Center
Bismarck, North Dakota 58505

Dear Mr. Sperry:

This responds to your letter of May 28, 1986 expressing concerns that the Corps flood control study of the Souris River basin address the effects of construction of the project on cultural resources in Canada. We appreciate your concerns about the potential loss of the Northern Great Plains archeological data base, and we assure you that all appropriate measures are being taken to record and preserve the cultural sites of this area.

Archeological field work on Rafferty Reservoir was initiated in 1984 with an intensive survey of the damsite, the spillway, and the area of the power plant. In addition, a sample survey of the reservoir area was made. This work will be incorporated into the EIS (Canadian) which is not yet completed. Work at Rafferty Dam has focused on the dam, spillway, and power plant because of a scheduled construction start of fiscal year 1987. Field work at Rafferty and Alameda Dams will continue over the next several field seasons. While no archeological field work has been conducted at Alameda Dam as yet, a reconnaissance survey is planned for this field season.

Cultural resources work being conducted in Saskatchewan will not come under the purview of the National Historic Preservation Act or other Federal laws and regulations of the United States government. Archeological survey, assessment, and mitigation of significant resources will be conducted under the authority of the Heritage Resources legislation of Saskatchewan. Archeological work directly associated with the flood control features of Alameda and Rafferty Dams will be conducted by the Canadians under their legislation but will be paid for with funds transferred to them by the United States.

We hope that this letter has addressed your concerns. Should you have any questions about the flood control project, please contact Mr. David Berwick of my staff at (612) 725-7854. For copies of the EIS and questions concerning the Canadian portion of the project, you may contact Mr. Ray Kenny, Environmental Programs, Saskatchewan Power Corporation, 2025 Victoria Avenue, Regina, Saskatchewan S4P0S1. Mr. Kenny can be reached at (306) 566-2881.

Sincerely,

Louis Kowalski

Louis Kowalski
Chief, Planning Division

Advisory Council On Historic Preservation

The Old Post Office Building
1100 Pennsylvania Avenue, NW. #809
Washington, DC 20004

Reply to: 730 Simms Street, Room 450
Golden, Colorado 80401

August 29, 1986

Colonel Joseph Briggs
District Engineer
St. Paul District
Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, MN 55101-1479

REF: Souris River Flood Control project, affecting historical properties in North Dakota and Canada

Dear Colonel Briggs:

It has come to the Council's attention that this project will affect northern Great Plains archeological sites and other historical properties in both the United States and Canada. The properties in the United States may be included in or eligible for inclusion in the National Register of Historic Places. The sites in Saskatchewan may merit preservation planning in accordance with that Province's or Canada's historic preservation legislation. We understand the Corps proposes to transfer funds to the Province to pay for work conducted on historical properties.

In accordance with Section 106 of the National Historic Preservation Act, the nature of this project's effects on historical properties in the United States may require the Corps to obtain the comments of the Council, and Sections 2(2) and 402 of the National Historic Preservation Act place affirmative preservation responsibilities on Federal agencies regarding properties outside the United States. In particular, Section 402 specifices that "Prior to the approval of any Federal undertaking outside the United States which may directly and adversely affect a property which is on the World Heritage List or on the applicable country's equivalent of the National Register, the head of a Federal Agency having direct or indirect jurisdiction over such undertaking shall take into account the effect of the undertaking on such property for purposes of avoiding or mitigating any adverse effects." As part of its advisory responsibilities, the Council is ready to assist the Corps in fulfilling its responsibilities under Section 402 of the Act.

We request that the Corps investigate to determine whether the Council's comments must be obtained in accordance with Section

106 of the National Historic Preservation Act regarding affected historical properties in the United States. We also request that the Corps investigate to determine whether we may be of assistance in fulfilling its responsibilities under Section 402 of the Act.

We look forward to receiving your response on these matters.

If there are any questions or we may be of assistance, please contact Brit Storey of this office at (303) 236-2682 or at 776-2682 on the FTS system.

Sincerely,

Robert Fink
Chief, Western Division
of Project Review

Souris Basin Development Authority

November 10, 1986

Mr. Dave Berwick
Environmental Resources Branch
U.S. Army Corps of Engineers
St. Paul District
1135 U.S. Post Office & Custom House
St. Paul, Minnesota
U.S.A.
55101-1479

Dear Sir:

Please find attached a <u>draft</u> copy of "An Archaeological Inventory of a Proposed Thermal Electric Plant and Associated Reservoir near Estevan, Saskatchewan". I underscore the fact that this is a draft report and that once finalized, I will send you a final copy. Should you have any questions, please call.

Sincerely,

GEORGE N. HOOD
DIRECTOR OF PLANNING AND OPERATIONS

:jal
Enclosure

cc - Ray Kenny

[illegible] 4th Street
[illegible]

APPENDIX 3

EIS Distribution

Exec. Sec., Nat. Res. & Envir. Committee
Room 242-W, Admin. Bldg., USDA
14th St. & Independence Ave., SW
Wash., D.C. 20250-0001

Agricultural Research Service
Room 125, Bldg. 005
Agriculture Research Center-West
Beltsville, MD 20705-2350

Planning and Evaluation, ASCS
Room 4714, S. Agriculture Bldg.
P.O. Box 2415
Wash., D.C. 20013-2415

Nat. Resource Economics Div.
Economic Research Service
500 12th St., SW, Room 412, GHI Bldg.
Wash., D.C. 20250-0001

Nat. Res. & Rural Development, Ext. Service
Room 3909, S. Agriculture Bldg.
14th St. & Independence Ave., SW
Wash. D.C. 20250-0001

Farmers Home Administration, Env. Prot. Spec.
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14th St. & Independence Ave., SW
Wash., D.C. 20250-0001

Rural Electrification Administration
Room 1257, S. Agriculture Bldg.
14th St. & Independence Ave., SW
Wash., D.C. 20250-0001

Nat. Env. Coordinator, SCS
Room 6155, S. Agriculture Bldg.
P.O. Box 2890
Wash., D.C. 20013-2890

Forest Service, Env. Coord.
Room 4204, S. Agriculture Bldg.
P.O. Box 2417
Wash., D.C. 20013-2417

Ecol. and Conserv. Div., NOAA
Room H6111, Herbert Hoover Blvd.
14th St. and Constitution Ave., NW
Wash., D.C. 20230-0001

Dir., Office of Envir. Compliance, DOE
Room 4G-085, Forrestal Bldg.
1000 Independence Ave., SW
Wash., D.C. 20585-0001

Office of Mgmt. Analysis & Systems, HHS
Room 542, E. Hubert H. Humphrey Bldg.
200 Independence Ave., SW
Wash., D.C. 20201-0001

Dir., Office of Envir. & Energy
Room 7154, HUD Bldg.
451 Seventh St., SW
Wash., D.C. 20410-0001

Dir., Office of Envir. Proj. Review
Room 4241, Interior Bldg.
18th and C Streets, NW
Wash., D.C. 20240-0001

Dir., Reg. Econ., Dept. of Labor
Room S-2312, Frances Perkins Bldg.
200 Constitution Ave., NW
Wash., D.C. 20210-0001

Dir., Office of Envir. & Health
Room 4325, State Dept. Bldg.
21st and C Streets, NW
Wash., D.C. 20520-0001

Office of Marine Envir. & Systems
U.S. Coast Guard
2100 2nd St., SW
Wash., D.C. 20593-0001

Dir., Office of Cultural Res. Preservation
Old Post Office Bldg., Suite 803
1100 Pennsylvania Ave.
Wash., D.C. 20004-2590

Dir., Office of Fed Activities
Envir. Protection Agency
Room 2119-I, 401 M St., SW
Wash., D.C. 20460-0001

Associate General Counsel
Federal Emerg. Mgmt. Agency
Room 840, 500 C St., SW
Wash., D.C. 20472-0001

Env & Policy Review
Office of Economics
Dept. of Transportation
Washington, D.C. 20590

Basin & Area Plan.
Room 5240 - South, USDA
SCS, P.O. Box 2890
Washington, D.C. 20013

Colorado State Office, BLM
Water Power Sect (CO-941 D)
1037 20th Street
Denver, Colorado 80202

Dir. of Waterway Studies
Assoc. of American Railroads
1920 L Street NW
Washington, D.C. 20036

National Audubon Society
Suite 330 City Place
730 Hennepin Avenue
Minneapolis, MN 55403

Izaak Walton League of Amer.
Suite 806
1800 North Kent Street
Arlington, VA 22207

Advisory Council on Historic
Preservation
1522 K Street NW
Washington, D.C. 20005

Asst. Director
U.S. Geological Survey
12201 Sunrise Valley Drive
Reston, VA 22092

Documents Librarian
Colorado State University
Fort Collins, CO 80523

Division Superintendent
Midwestern Gas Transmission
P.O. Box 70
Wadena, MN 56482

Forest Service
USDA
Federal Bldg., P.O. Box 7669
Missoula, MT 59807-7669

Federal Region VIII
U.S. Dept. of Housing & Urban Dev.
Exec. Tower Bldg., 1405 Curtis St.
Denver, CO 80202-2394

Federal Regions VII and VIII
U.S. Dept. of Transportation
601 E. 12th St., Room 634
Kansas City, MO 64106-2879

Regional Director
Fed. Aviation Administration
2300 East Devon Avenue
Des Plaines,IL 60018-4686

Federal Region VIII
Federal Highway Administration
555 Zang St., P.O. Box 25246
Denver, CO 80225-0246

Commander
Second Coast Guard District
1430 Olive Street
St. Louis, MO 63103-2398

Federal Region VIII
U.S. Environmental Protection Agency
Suite 900, Lincoln Tower
1860 Lincoln Street
Denver, CO 80295-0699

Intergovernmental Assistance
Office of Manag. and Budget
14th Floor - State Capitol
Bismarck, ND 58505

League of Women Voters
703 2nd Avenue South
Fargo, ND 58103

State Conservationist
Soil Cons. Service
Federal Bldg., P.O. Box 1458
Bismarck, ND 58501

ND Coordinator, Custer NF
1824 North 11th Street
Bismarck, ND 58501

Region VIII
U.S. EPA
1860 Lincoln Street
Denver, CO 80295

Garrison Diver. Conserv. Dist.
Box 140
Carrington, ND 58421

Div. of Cultural Programs
National Park Service
655 Parfet Street
Denver, CO 80225

Chief, IAS
National Park Service
655 Parfet St., Box 25287
Denver, CO 80225

Dept. of Health & Human Serv.
1961 Stout Street
FOB, Room 11037
Denver, CO 80294

Administrator
HUD, Region VIII
1405 Curtis Street
Denver, CO 80202

Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486, DFC
Lakewood, CO 80225

Field Supervisor-Environment
U.S. Fish and Wildlife Service
1500 Capitol Avenue
Bismarck, North Dakota 58501

Bureau of Indian Affairs
Federal Building
Aberdeen, SD 57401

Bureau of Land Management
Box 1072
Dickinson, ND 58601

Intermountain Field Opns.
Bureau of Mines
Bldg. 20, Denver Fed. Center
Lakewood, CO 80225

Director
National Park Service
Rocky Mountain Region
P.O. Box 25287
Denver, CO 80225

Colorado State Office, BLM
Water Power Sect (CO-941 D)
1037 20th Street
Denver, Colorado 80202

U.S. Geological Survey
MS101, Denver Federal Center
Box 25406
Denver, CO 80225

District Chief
U.S. Geological Survey
821 East Interstate Avenue
Bismarck, ND 58501

NOAA, National Marine Fisheries
7600 Sand Point Way N.E.
Bin C15700
Seattle, WA 98115

U.S. Fish and Wildlife Service
Endangered Species Office
P.O. Box 250
Pierre, South Dakota 57501

State Hist. Pres. Officer
State Hist. Soc. of ND
ND Heritage Center
Bismarck, ND 58505

N.D. Dept. of Agriculture
State Capitol
Bismarck, ND 58505

Department of Anthropology
University of North Dakota
Grand Forks, ND 58501

Attorney General's Office
State Capitol
Bismarck, ND 58505

Clearinghouse-Fed. Aid
Coord. Office
First Floor-State Capitol
Bismarck, ND 58505

Dr. Robert Johnson, State Forester
Dean, School of Forestry
N.D. State Univ. - Bottineau
Bottineau, ND 58318

District Forester
North Dakota Forest Service
Bottineau, ND 58318

Commissioner
N.D. Game & Fish Dept.
2121 Lovett Avenue
Bismarck, ND 58505

North Dakota Geological Sur.
University of North Dakota
Grand Forks, ND 58201

Administrator
ND Dept. of Health
State Capitol
Bismarck, ND 58505

North Dakota Hwy. Dept.
State Highway Building
Bismarck, ND 58505

Executive Director
North Dakota Indian Aff. Comm.
Belcourt, ND 58316

North Dakota Land Dept.
State Capitol
Bismarck, ND 58505

Director
N.D. State Planning Div.
State Capitol
Bismarck, ND 58505

Reclamation Director
Public Serv. Comm. of N.D.
State Capitol
Bismarck, ND 58505

Executive Officer
North Dakota Parks &
Recreation Dept.
P.O. Box 700
Bismarck, ND 58502

Executive Secretary
North Dakota Soil Cons. Comm.
State Capitol
Bismarck, ND 58502

Chief Engineer
North Dakota Water Commission
900 East Boulevard
Bismarck, ND 58505

Documents Department
Memorial Library
Minot State College
Minot, ND 58701

Documents Librarian
Colorado State University
Fort Collins, CO 80523

ND State University Library
ATTN: Documents Librarian
Fargo, ND 58105

University of North Dakota
Library
ATTN: Documents Librarian
Grand Forks, ND 58201

Veterans Memorial Library
520 Avenue A. East
Bismarck, ND 58501

Old West Regional Commission
1823 W. Main
Rapid City, SD 57701

Lake Agassiz Reg. Council
Suite 205, South Plaza
1621 South University Dr.
Fargo,ND 58103

National Audubon Society
North Midwest Regional Office
Box 1591
Jamestown, ND 58401

Federal Railroad Administration
Room 2120, Nassif Bldg.
400 Seventh St., SW
Wash., D.C. 20590-0001

International Boundary & Water Commission
United States Section
IBWC Bldg., 4110 Rio Bravo
El Paso, TX 79902-1091

The Waterways Journal
666 Security Building
319 North Fourth Street
St. Louis, MO 63102

North Central Region
National Wildlife Federation
710 2nd Street NW
Mandan, ND 58554

Water Res. & Coastal Cons. Prog.
National Wildlife Federation
1412 Sixteenth Street, N.W.
Washington, D.C. 20036

Environ. Defense Fund, Inc.
1525 18th Street NW
Washington, D.C. 20036

Hon. Mark Adams
State Senator
R.R.
Lansford, ND 58750

Hon. Hal Christensen
State Senator
307 Eighth St., NW
Minot, ND 58701

Hon. Rolland Redlin
State Senator
1005 21st NW
Minot, ND 58701

Hon. Chester Reiten
State Senator
2021 Ida Mae Ct.
Minot, ND 58701

Hon. Marvin E. Sorum
State Senator
701 First Ave., NE
Kenmare, ND 58746

Hon. Jerome L. Walsh
State Senator
Rt. 1
Minot, ND 58701

Hon. Stanley Wright
State Senator
Box 97
Stanley, ND 58784

Hon. Charles Anderson
State Representative
Rt. 1, Box 113
Voltaire, ND 58792

Hon. Richard J. Backes
State Representative
Glenburn, ND 58740

Hon. Orlin Hanson
State Representative
Rt. 2, Box 22
Sherwood, ND 58782

Hon. Brynhild Haugland
State Representative
P.O. Box 1684
Minot, ND 58701

Hon. Carolyn Houmann
State Representative
Westhope, ND 58793

Hon. Franklin Huwe
State Representative
620 10th Ave., SE
Minot, ND 58701

Hon. David Koland
State Representative
801 Clark Dr.
Minot, ND 58701

Hon. Lawrence D. Marsden
State Representative
413 Spruce St.
Bottineau, ND 58318

Hon. Douglas Mattson
State Representative
330 11th St., NW
Minot, ND 58701

Hon. Jim Peterson
State Representative
516 Eighth St., NW
Minot, ND 58701

Hon. Ryden Reud
State Representative
Box 1666
Minot, ND 58701

Hon. Jim Sorum
State Representative
Flaxton, ND 58737

Hon. Mike Timm
State Representative
P.O. Box 29
Minot, ND 58701

Hon. Janet Wentz
State Representative
505 Eighth Ave., W.
Minot, ND 58701

Senator Quentin N. Burdick
United States Senator
Senate Office Building
Washington, D. C. 20510

Senator Mark Andrews
United States Senate
Washington, D. C. 20510

Honorable Byron Dorgan
House of Representatives
House Office Building
Washington, D. C. 20515

Mrs. Erma Aalund
P.O. Box 572
Mohall, ND 58761

Bruce C. Adams
2510 Bel Air Court
Minot, ND 58701

Mark & Julie Adams
RR 2
Lansford, North Dakota 58750

Mr. Ray Albers
Rural Route
Foxholm, ND 58738

Mr. Harold E. Anderson
Velva, ND 58790

Mr. Harvey Anderson
Carpio, ND 56725

Mr. Dan Arnold
Carpio, N. Dak. 56725

Mr. Stephen Ashley
Velva, ND 58790

Mr. Marvin Axness
Carpio, N. Dak. 56725

Mr. Roy Axness
Carpio, ND 56725

Mr. Harold Bader
13 Souris Court
Minot, ND 58701

Mrs. John Bahn
Foxholm ND 58738

Carrol Bakken
Voltaire, ND 58792

Mr. Michael Bauer
Rural Route
Tolley, ND 58787

Mr. Richard A. Beall
Velva, ND 58790

Mr. Leon Becker
Des Lacs, ND 58733

Ms. Helene Benson
Sherwood, ND 58782

Mrs. Agnes Berge
Velva, ND 58790

Mr. Donovan Bertuk
Bottineau, ND 58318

Mr. John A. Beruesen
Denbigh, ND 58732

Mr. Walley Beyer
Velva, ND 58790

Mr. Donald Bivins
Sawyer, ND 58781

Mr. Daniel Bloms
Foxholm, ND 58738

Mr. Ralph Bloms
Rural Route
Lansford, ND 58750

Mr. Donald Boll
Newburg, ND 58762

Raymond Boll
Newburg, ND 58762

Mr. Kenneth Booth
Towner, ND 58788

Mrs. David Bowe
209 Linden Avenue South
Fargo, ND 58102

Mr. Ewald S. Braun
Foxholm, ND 58738

Mr. Herman Braun
Foxholm, ND 58738

Mr. Perry Braun
Sherwood, ND 58782

Dr. A. B. Brudirk
D.D.S. Office
Mohall, ND 58761

Mr. Clifford Burbidge
Mohall, ND 58761

Mr. Paul Burgess
Velva, ND 58790

Mr. Leland Burtness
1932 1st Ave. SW
Minot, ND 58701

[illegible] Buzzell
[illegible] 1st Ave. SW
Minot, ND 58701

[illegible] Cantlon
[illegible] 58712

Mr. Jacob E. Carlson
Rural Route
Lansford, ND 58750

Mr. Vernon Carlson
Glenburn, ND 58740

Mr. Lee D. Christensen
Kenmare, ND 58746

Mr. John Clouse
Rural Route
Foxholm, ND 58738

Mrs. Veronica Clouse
Rural Route
Foxholm, ND 58701

Mr. Eldon J. Cook
Norman, ND 58766

Mr. Howard Coss
Towner, ND 58788

Mr. Kenneth D. Crites
2036 California Drive
Minot, ND 58701

Mr. Al J. Cutz
Antler, ND 58711

Mr. M. O. Dahle
Box 1796
Minot, ND 58701

Mr. Clifford Dahlseng
Carpio, ND 58725

Mr. Warren Dailey
Sherwood, ND 58782

Mr. C. R. Danks
Route 2
King's Court
Minot, ND 58701

Mr. Eugene G. Davidson
Tolley, ND 58787

Mr. Godfrey G. Davidson
Tolley, ND 58787

Mr. and Mrs. Donald DeGree
Rural Route
Foxholm, ND 58738

Dr. Dennis Disrud
413 Hillcrest Drive
Minot, ND 58701

Mr. Duane Dokken
1021 NW Eighth
Minot, ND 58701

President
Village of Burlington
Burlington, ND 58722

McHenry County Water Management Board
Granville, ND 58741

Mr. James A. Rodacher
County Tax Director
Mohall, ND 58644

Carpio Public School District
Carpio, ND 58725

Mr. Robert Laumb
McKinney Township Sup.
Tolley, ND 58787

Mayor
City of Mohall
Mohall, ND 58761

Mayor
City of Carpio
Carpio, ND 58725

Dr. Lowell Latimer
Board of Education
Minot, ND 58701

Auditor
Renville County
Mohall, ND 58761

President
Village of Des Lacs
Des Lacs, ND 58783

City Manager
City of Minot
Minot, ND 58701

Chairman, Board of County Commissioners, Renville Co.
Mohall, ND 58761

Superintendent
Granville Public School Dist.
Granville, ND 58741

Assistant Minot City Engineer
Minot, ND 58701

Highway Engineer
Renville County
Mohall, ND 58761

City Clerk
City of Kenmare
Kenmare, ND 58746

Finance Director
City of Minot
Minot, ND 58701

President
Village of Sawyer
Sawyer, ND 58781

Mayor
ATTN: Auditor
Kenmare, ND 58746

Mayor
City of Minot
Minot, ND 58701

President
Village of Surrey
Surrey, ND 58785

Auditor
McHenry County
Towner, ND 58788

Minot Park District
Minot, ND 58701

President
Village of Towner
Towner, ND 58788

Highway Engineer
McHenry County
Towner, ND 58788

Minot City Planning Board
Minot, ND 58701

Treasurer
Village Towner
Towner, ND 58788

Chairman, Board of County Commissioners, McHenry Co.
Towner, ND 58788

City Clerk
City of Mohall
Mohall, ND 58761

Assessor
City of Velva
Velva, ND 58790

Mr. Oscar Gilbertson
Rural Route
Sherwood, ND 58782

Dr. M. Byron Grubb
600 17th Ave. SE
Box 1489
Minot, ND 58701

Mr. Walter Gillstad
Voltaire, ND 58792

Mr. Mike Gugoire
Donnybrook, ND 58734

Mr. Glen Froseth
Kenmare, ND 58746

Mr. Norman Gjellstad
Velva, ND 58790

Conrad Haarsager
Mohall, ND 58761

Mr. Donovan Funke
Greene
Tolley, ND 58787

Robert Gjellstad
RR 1 Box 90
Voltaire, ND 58792

David B. Hall
Newburg, ND 58762

Norwin L. Fylling
421 East 5th St.
Bottineau, ND 58318

Mr. George Gorde
Foxholm, ND 58738

Ms. Diane Halverson
Route 1
Northfield, MN 55057

Dr. and Mrs. Gamme
Kenmare, ND 58746

Mr. Burton Graff
Carpio, ND 56725

Mr. Orlin Hanson
Sherwood, ND 58782

Mr. Michael Gates
Lansford, ND 58750

Mr. Dale Graff
Carpio, ND 56725

Mr. Robert S. Hanson
Sherwood, ND 58782

Mr. David Gilbertson
Sherwood, ND 58782

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Souris, ND 58783

Mr. Aibrey Harkness
Sherwood, ND 58782

Mr. Elmer Gilbertson
Rural Route
Sherwood, ND 58782

Mr. David Gray
Carpio, ND 56725

Mr. & Mrs. Elmer Harkness
Sherwood, ND 58782

Mr. Norman Gilbertson
Sherwood, ND 58782

Mr. Larry Hauser
Foxholm, ND 58738

Mr. Bruce Helseth
NDFU
Carpio, ND 58725

Mr. Darrell S. Helseth
Carpio, ND 56725

Mr. Bryce Henderson
Sherwood, ND 58782

Mr. Quentin Hennenfent
820 16th Ave. SW
Minot, ND 58701

Mr. Art Herther
240 Souris Drive
Minot, ND 58701

Mr. Carl J. Herzig
Rural Route
Burlington, ND 58722

Mr. Floyd Herzig
Rural Route
Burlington, ND 58722

Mr. Lloyd Heusers
110 Sencond Avenue SE
Minot, ND 58701

Mr. Earnest Hoelscher
Rural Route
Foxholm, ND 58701

Mr. Charles Hoffman
844 10th Ave. NW
Minot, ND 58701

Mr. James Hombier
Tolley, ND 58787

Mr. Vince Horner
Upper Souris Water
Mohall, ND 58644

Mr. Valdmar Hovde
707 SW 12th
Minot, ND 58701

Mr. & Mrs. Clayton Howe
Box 432
Velva, ND 58790

Mrs. Shirley K. Hunt
5600 Hillside Court
Minneapolis, MN 55435

Mr. Bob Inman
Kenmare, ND 58746

Mr. Kenneth L. Johnson
Burlington, ND 58722

L. Wilbur & Lois L. Johnson
RR 1
Mohall, ND 58761

Mr. & Mrs. Lloyd Johnson
Sherwood, ND 58782

Nora Johnson
Box 563
Mohall, ND 58761

Palmo Johnson
Route 1
Mohall, ND 58761

Mr. Paul Johnson
Carpio, N. Dak. 56725

Dr. Richard W. Johnson
208 Souris Drive
Minot, ND 58701

Mr. & Mrs. Richard Johnson
Tolley, ND 58787

Mr. Thor Johnson
Number 9 Greenway
Minot, ND 58701

Mr. Dale Keith
Sherwood, ND 58782

Mr. Byron Duerre
Norman, ND 58766

Messrs. Ben and Don Eckert
Foxholm, ND 58738

Mr. Fred Ehr
North Burlington Road
Minot, ND 58701

Douglas Eiken
State Parks and Recreation
Rt. 2, Box 139
Mandan, ND 58554

Mr. Lowell Elberg
Carpio, ND 58725

Mr. Evan Elnestad
Foxholm, ND 58738

Ms. Agnes Elvestad
Foxholm, ND 58738

Mr. Steve Emerson
Rural Route
Mohall, ND 58761

Mrs. JoAnn Emmel
Sherwood, ND 58782

Mr. Dennis R. Emmel
Sherwood, ND 58782

Mr. Doyle Emmel
Sherwood, ND 58782

Mr. Herbert Emmel
Kenmare, ND 58746

Ms. Nancy Emmel
Sherwood, ND 58782

Mr. Allan Engl
Sherwood, ND 58782

Mr. Willard Erdman
2800 Ninth Ave. SE
Minot, ND 58701

Mr. Alan Erickson
Carpio, N. Dak. 56725

Mr. Clifford Erickson
Carpio, ND. 56725

Ms. Joyce Ann Espeseth
Denbigh, ND 58732

Ms. Lillian Espeseth
Denbigh, ND 58732

Mr. Myron Espeseth
Denbigh, ND 58732

Mr. Curtis Feist
Velva, ND 58790

Ora Fischer
Mohall, ND 58761

Mr. & Mrs. Harry Flaherty
Berthold, ND 58718

Mr. Harlen Flaten
Carpio, N. Dak. 56725

Mr. H.E. Follman
Towner, N. Dak. 58788

Mr. Ivan Foss
Sherwood, ND 58782

Mr. Joseph Keller
Coast to Coast Store
Velva, ND 58790

Mr. Joe Kennedy
Foxholm, ND 58738

Mr. Donald Keyes
Nine Little Ponderosa
Minot, ND 58701

Mr. Albert Klain
Turtle Lake, ND 58575

Mr. Glen D. Klebe
236 Souris Drive
Minot, ND 58701

Mr. Vernon Knogslie
Denbigh, ND 58732

Mr. H. Knudsen
325 11th Street NW
Minot, ND 58701

Mr. Alvin Knutson
Rural Route
Sherwood, ND 58782

Mr. & Mrs. John Knutson
Sherwood, ND 58782

Mr. Marvin Knutson
401 Second Avenue
Mohall, ND 58761

Mr. W.F. Kosel
Sherwood, ND 58782

Mr. Alvin A. Kramer
1205 13th Street
Minot, ND 58701

Ms. Anna L. Krenz
P.O. Box 293
Mohall, ND 58761

Mrs. Paul Krenz
Sherwood, ND 58782

Mr. Craig Kuth
Sherwood, ND 58782

Mr. Roy Laframboise
Towner, ND 58788

Mr. Ervin Lakefield
Sherwood, ND 58782

Mr. Gilmore V. Landis
230 Souris Drive
Minot, ND 58701

Mr. Laurets Larson
Denbigh, ND 58732

Ms. Myrtle C. Larson
2009 West Central
Minot, ND 58701

Mr. Harold I Leavitt
402 Second Avenue NW
Mohall, ND 58761

Mr. Art Lee
Carpio, ND 56725

Mr. Don Lee
Carpio, N. Dak. 56725

Mrs. Dorothy Lee
Carpio, N. Dak. 56725

Mr. Gary Lenton
Norwich, ND 58768

Mr. Gordon H. Lewis
Carpio, N. Dak. 56725

Mr. Ken Livedalen
Towner, ND 58788

Mr. Allan Livingston
Kenmare, ND 58746

Mr. Carl Loftesnes
Velva Lumber Company
Velva, ND 58790

Mr. Glenn E. Long
Bottineau, ND 58318

Mr. John McCanna
7020 Kellogg Ave. S.
Edina, MN 55434

Mr. E.C. McCarroll
Tolley, ND 58787

Ms. Genevieve McDermott
Sherwood, ND 58782

Mr. Howard McGuire
Carpio, ND 56725

Mr. O.L. McNea
313 NW 21st
Minot, ND 58701

Mr. Erling Markusen
Denbigh, ND 58732

Mr. Lynn Martin
Route 2
Minot, ND 58701

Mr. Dennis G. Mattern
Rural Route
Mohall, ND 58761

Mr. Gil Melland
Kenmare, N D 58746

Mrs. Jack Miller
Lansford, ND 58750

Mr. John E. Miller
Box 427
Towner, ND 58788

Mr. Kyle Miller
Bantry, ND 58713

Mr. Norman Moen
Granville, ND 58741

Mr. Dick Morton
Carpio, ND 56725

Ms. Elsie Mott
Sherwood, ND 58782

Mr. Ernest Mott
Sherwood, ND 58782

Mr. A.R. Moum
Box 1458
Bismarck, ND 58501

Mr. Marvin Murphy
Donnybrook, ND 58734

Mr. Richard Musch
Burlington, ND 58722

Mr. Donald Myers
Rt. #6
Minot, N. Dak. 58701

Mr. Lowell Myers
Carpio, ND 56725

Mr. Clifford L. Nelson
Sherwood, ND 58782

Mr. Farrel Nelson
Towner, ND 58788

Mr. Laurence Nelson
Denbigh, ND 58732

Mr. & Mrs. Nelson
Denbigh, ND 58732

Mr. Stan Nelson
R.R. 6
Minot, ND 58701

Mr. Lyle Newhouse
Sherwood, ND 58782

Mr. Kenneth Niewohner
Deering, ND 58731

Mr. Lloyd Nygard
Route 6
Minot, ND 58701

Mr. John Odland
Kenmare, ND 58746

Mr. & Mrs. C. L. O'Keefe
Lansford, ND 58750

Mr. Lawrence Olesen
Sherwood, ND 58782

Mr. James W. Olson
Velva, ND 58790

Mr. Sidney Olson
Rural Route
Mohall, ND 58761

Ms. JoAnne Ones
Tolley, ND 58787

Mrs. Chris Ones
Rural Route
Tolley, ND 58787

Mr. Curtis Ones
Tolley, ND 58787

Mr. & Mrs. Harry Ostlund
Tolley, ND 58787

Ms. Jany Overton
Norma, ND 58766

Mr. Gary L. Pearson
Route 2
Jamestown, ND 58401

Mr. Don Perkuchin
Box 12
Foxholm, ND 58738

Mr. Dallas Perron
Sherwood, ND 58782

Mrs. Fannie F. Peters
Towner, N. Dak. 58788

Mr. S.E. Peterson
1916 Seventh St. NW
Minot, ND 58701

Mr. Donald Peterson
Berthold, ND. 58718

Mr. Donald D. Peterson
Carpio, N. Dak. 56725

Mr. Kenneth Pfiffner
119 Sixth St. NW
Minot, ND 58701

Mr. Harold Piper
1508 Third Avenue SW
Minot, ND 58701

Messrs. John & Dick Pritschet
Foxholm, ND 58738

Mr. Donald Rademacher
Foxholm, ND 58738

Mr. Frank Rademacher
Rural Route
Foxholm, ND 58738

Mr. Gene Ramsdell
Kenmare, ND 58746

Miss Barbara Rebor
11-9 SW Davenport St.
Portland, OR 97201

Mr. Duane Roen
Lansford, ND 58750

Mr. Kenneth Niewohner
Deering, ND 58731

Mr. Lloyd Nygard
Route 6
Minot, ND 58701

Mr. John Odland
Kenmare, ND 58746

Mr. & Mrs. C. L. O'Keefe
Lansford, ND 58750

Mr. Lawrence Olesen
Sherwood, ND 58782

Mr. James W. Olson
Velva, ND 58790

Mr. Sidney Olson
Rural Route
Mohall, ND 58761

Ms. JoAnne Ones
Tolley, ND 58787

Mrs. Chris Ones
Rural Route
Tolley, ND 58787

Mr. Curtis Ones
Tolley, ND 58787

Mr. & Mrs. Harry Ostlund
Tolley, ND 58787

Ms. Jany Overton
Norma, ND 58766

Mr. Gary L. Pearson
Route 2
Jamestown, ND 58401

Mr. Don Perkuchin
Box 12
Foxholm, ND 58738

Mr. Dallas Perron
Sherwood, ND 58782

Mrs. Fannie F. Peters
Towner, N. Dak. 58788

Mr. S.E. Peterson
1916 Seventh St. NW
Minot, ND 58701

Mr. Donald Peterson
Berthold, ND 58718

Mr. Donald D. Peterson
Carpio, N. Dak. 56725

Mr. Kenneth Pfiffner
119 Sixth St. NW
Minot, ND 58701

Mr. Harold Piper
1508 Third Avenue SW
Minot, ND 58701

Messrs. John & Dick Pritschet
Foxholm, ND 58738

Mr. Donald Rademacher
Foxholm, ND 58738

Mr. Frank Rademacher
Rural Route
Foxholm, ND 58738

Mr. Gene Ramsdell
Kenmare, ND 58746

Miss Barbara Rebor
11-9 SW Davenport St.
Portland, OR 97201

Mr. Duane Roen
Lansford, ND 58750

Mr. Larry Roggenbuck
Carpio, N. Dak. 56725

Mr. Vernon Rom
Denbigh, ND 58732

Mr. Harlon Rostod
Carpio, ND 56725

John Royer
Winacre Drive
Lafayette, NY 13084

Mr. Paul Satterlund
Carpio, N. Dak. 56725

Mr. Harold Sauer
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Minot, ND 58701

Mr. Lawrence Scheresky
Des Lacs, ND 58733

Mr. Martin Schiffman
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Lynn Schipp
Box 81
Newburg, ND 58762

Ms. Patricia Schmidt
Rural Route
Burlington, ND 58722

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Voltaire, ND 58792

Mr. Willis Schultz
Carpio, ND 56725

Mr. David Schupp
Norma, ND 58766

Mr. Ves Schuster
2914 Second Ave. SW
Minot, ND 58701

Mr. Myron Sebastian
Towner, ND 58788

Mr. Laurence Servold
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Mohall, ND 58761

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Henry and Mary Stammer
RR 6
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Mr. Reuben Steffan
2019 Second Ave. SW
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15 Souris Court
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Mohall, ND 58761

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Mr. Richard Thoms
R.R. 6
Minot, ND 58701

Dale & Peggy Thorenson
Box 56
Newburg, ND 58762

Ms. Betty Thorp
Carpio, ND 56725

Mr. Peter Thorp
Carpio, ND 56725

Mr. Alvin Vaagen
Carpio, ND 56725

Ms. Louise Vaagen
Carpio, ND 56725

Mr. M.D. Vanerstrom
Carpio, ND 58725

Mrs. Pauline A. Vanerstrom
Carpio, N. Dak. 56725

Mrs. Leo N. Vassar
1530 Fourth Avenue SE
Minot, ND 58701

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Lansford, ND 58750

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Rural Route
Mohall, ND 58761

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Rural Route
Mohall, ND 58761

Mr. & Mrs. Roger Yale
Tolley, N. Dak. 58787

Mr. Robert G. Yos
Sherwood, N. Dak. 58782

Isadore Zimney
Lansford, ND 58750

Mr. Melvin H. Nelson
SR 3, Box 64
Towner, ND 58788

Grant County Public Library
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Milbank, SD 57252

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Library
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Morris, MN 56267

Birchwood Press
P.O. Box 20055
Denver, CO 80220

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Bismarck, ND 58501

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Fargo, ND 58101

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Grand Forks, ND 58201

Journal-Registry
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Minneapolis Star & Tribune
425 Portland Avenue
Minneapolis, MN 55415

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Minot, ND 58701

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Towner, ND 58788

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Mohall, ND 58761

St. Paul Pioneer Press and
Dispatch
55 East Fourth St.
St. Paul, MN 55101

Commissioners
City of Velva
Velva, ND 58790

Mr. Martin Clausen
McKinney Cemetery
Norman, ND 58766

President
City of Velva
Velva, ND 58790

C. S. McCrossan, Inc.
P.O. Box A-D
Osseo, MN 55369

Velva Park Board
Velva, ND 58790

R.J. Lemay
Research Analyst
Evinrude Motors
Milwaukee, WI 53216

Velva School Board
Velva, ND 58790

Mr. Daroll Thompson
Fire Protection D
Sherwood, ND 58732

Natl. Assn. Of River and
Harbor Contractors
536 Washington Bldg.
15th and New York Ave.
Washington, DC 20005

Mr. Arnold Hanson, Chairman
Walsh County Park Board
Grafton, ND 58237

Mr. Walter Rast
Intl. Joint Commission
1717 H St. NW, Room 203
Washington, DC 20440

Outboard Boating Club of
America
401 N. Michigan Ave.
Chicago, IL 60611

President, AFL-CIO
815 Sixteenth St. NW
Washington, DC 20006

C.R. Keller
Keller & Raymo
411 Sinclair Street
Bottineau, ND 58318

River & Harbor Imp. Assn.
218 West Becher St.
Milwaukee, WI 53207

Regional Office
AFL-CIO
175 Aurora Ave
St. Paul, MN 55103

President
ND League of Women voters
1625 S. 14 1/2 Street
Fargo, ND 58102

Chairman
Rush River Water Management
Board
Cass County Court House
Fargo, ND 58102

President
MN League of Women Voters
555 Wabasha St.
St. Paul, MN 55102

[illegible] Moore
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1100 Glendon Ave , Suite 1000
Los Angeles, CA 90024

Manager
Upper Souris National
Wildlife Refuge
RR #1
Foxholm, ND 58718

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Velva, ND 58790

Water Control News
4025 Peterson Avenue West
Chicago, IL 60646

KCJB Radio
Minot, ND 58701

KMOT-TV
Minot, ND 58701

KXMC-TV
Minot, ND 58701

Postmaster
Burlington, ND 58722

[illegible]tmaster
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Kenmare, ND 58746

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Minot, MN 58701

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Postmaster
Sawyer, ND 58781

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Postmaster
Velva, ND 58790

Dr. Mary Bromel
ND State University
Fargo, ND 58701

Dr. J. Frank Cassel
ND State University
Fargo, ND 58701

Center [illegible]
Studies, [illegible]
Universit[illegible]
Bemi[illegible]

Dr. Duane Dahlberg
Concordia College
Moorhead, MN 56560

Dr. Leonard B. Dworsky
Water Resources Center
Cornell University
468 Hollister Hall
Ithaca, NY 14850

Professor John C. Green
University of MN-Duluth
229 Science & Math Bldg.
Duluth, MN 55812

Guilford O. Fossum, PH.D.
Department of Civil Eng.
University of North Dakota
Grand Forks, ND 58202

Dr. Del Helgeson
ND State University
Fargo, ND 58701

Yung-Tse Hung, Ph.D.
Assistant Professor of Civil
Engineering
University of North Dakota
Grand Forks, ND 58202

North Dakota Acad[illegible]
Science
Universit[illegible]
Grand Forks, [illegible]

Dr. Pa[illegible]
Divis[illegible]
Minot [illegible]
[illegible]

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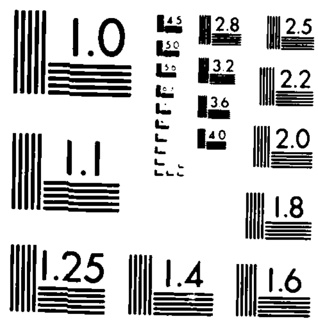

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Dr. Gene Phillips
Moorhead State University
Moorhead, MN 56560

Mr. Roger Richman
Moorhead State University
Moorhead, MN 56560

Dr. Donald Scoby
ND State University
Fargo, ND 58701

Dr. Bill Barker
Natural Science Society
ND State University
Fargo ND 58854

Mr. Mark Thornton
IES
University of ND
Grand Forks, ND 58201

Dr. Gerry Van Amburg
Concordia College
Moorhead, ND 56560

Dr. Bernard Youngquist
Supt., U of M Experiment Sta.
Crookston, MN 56716

Chief Engineer
Burlington Northern Inc.
176 East Fifth Street
St. Paul, MN 55101

Manager, Engineering
Burlington Northern Inc.
547 W. Jackson Blv.
Chicago, IL 60606

Division Engineer
Chicago-NW Transportation Co.
275 East Fourth St.
St. Paul, MN 55101

Vice President-Chief Eng.
Chicago-NW Transportation Co.
400 West Madison St.
Chicago, Il 60606

Vice Pres.-Chief Engineer
The Milwaukee Road, Union Station
516 West Jackson Blvd.
Chicago, IL 60606

MN Railroads Association
203 Hanover Bldg.
480 Cedar St.
St. Paul, MN 55101

Chief Engineer
Soo Line Railroad Co.
Soo Line Bldg.
Minneapolis, MN 55402

General Solicitor
Western Railroad Assoc.
222 S. Riverside Plaza
Chicago, IL 60606

J. Clark Salyer National
Wildlife Refuge
Upham, ND 58789

Coordinator
Souris River Basin Report
Box 1933
Minot, ND 58701

Power Supply Division
Southern Engineering Co.
1000 Crescent Ave. NE
Atlanta, GA 30309

Laverne C. Kreft
Vice President
State Bank of Towner
Towner, ND 58788

Orlin R. Oium
SR #2, Box 16
Towner, ND 58788

Watne Realtors, Inc.
408 North Broadway
Minot, ND 58701

Northcentral Field Rep.
Wildlife Management Institute
Route 2
Fargo, ND 58102

Mr. Mike Reynolds
Wisconsin Canoe Association
9021 F 91st Street
Milwaukee, WI 53224

US Army Eng. Dist., Wilmington
ATTN: SAWEP-PP/Mr. R. Phillips
PO Box 1890
Wilmington, NC 28401

Division Engineer
Fed. Hwy. Admn., U.S. DOT
P.O. Box 1755
Bismarck, ND 58501

Executive Director
ND Indian Affairs Comm.
Bottineau, ND 58318

Bureau of Land Management
Box 940
Miles City, MT 59301

Director
Technical Services Division
U.S. Dept. of HUD
451 7th Street SW
Washington, DC 20410

N.D. Outdoor Recreation Agenc
Box 139, Route 2
Mandan, ND 58554

Mr. Eric Wolfe
Bureau of Land Management
P.O. Box 729
Cedar, Utah 84720

Director
Architecture & Engrg. Div.
FHA, U.S. HUD
Washington, DC 20412

Neil Feist
Velva, ND 58790

Administrator, Area 3
BLM, USDI
Federal Center, Bldg. No. 50
Denver, Colorado 80202

Soil Conservation Service
Velva, ND 58790

Bureau of Reclamation
P.O. Box 2553
Billings, Montana 59103

Area Director
FHA, U.S. Dept. of HUD
P.O. Box 2483
Fargo, ND 58102

ND Water Users Association
P. O. Box 2254
Bismarck, ND 5802-2254

State & Private Forestry
U.S. Forest Service
370 Reed Road
Broomall, PA 19008

Missouri Basin Region
Office of the Sec'y. USDI
Bld. 67-Denver Fed. Center
Denver, Colorado 80225

Auditor
Bottineau County
Bottineau, ND 58318

Water Resources Activity
Vector Biology & Control Div.
Center for Disease Control
Atlanta, GA 30333

Chairman, Board of County
Commissioners, Bottineau Co.
Bottineau, ND 58318

Director
Civil Defense, DOD
Office of Civil Defense
Washington, DC 20310

Chief, Bureau of Power
Fed. Energy Reg. Comm.
Washington, D.C. 20426

Mr. Roger Nelson, President
Bottineau Chamber of Commerce
Bottineau, North Dakota 5831.

Division of NEPA Affairs
Department of Energy
Mail Station E-201, GTN
Washington, D.C. 20545

Governor Allen I. Olson
State Capitol
Bismarck, ND 58505

Highway Engineer
Bottineau County
Bottineau, ND 58318

Administrator, Fed. Hwy. Admin.
Bridge Division HND 31
400-7th Street SW
Washington, DC 20590

Director, Public Affairs
ND Farm Bureau
1101 1st Avenue N
Fargo, N. Dak. 58102

Bottineau County Water
Management Board
Kramer, ND 58748

J. Clouse
Route 1, Box 12
Foxholm, North Dakota 58738

Maryilyn Lawler
Assistant Director
Minot Public Library
516 Second Avenue S.W.
Minot, North Dakota 58701-3792

B. Vincent Viscomi
Department of Civil Engineering
Lafayette College
Easton, Pennsylvania 18042

United States Department of the Interior
Bureau of Mines
Building 20
Denver Federal Center
Denver, Colorado 80225

Mr. Richard Johnson
Tolley, North Dakota 58787

Carl Flagstad
Minot Daily News
Minot, North Dakota 58701

United State Department of Agriculture
Soil Conservation Service
P.O. Box 1458
Bismarck, North Dakota 58501

Dr. Dennis T. Disrud
Minot State College
Biology Department
Minot, North Dakota 58701

Mr. Harold Sauer
RR 1 Box 24
Glenburn, North Dakota 58740

Mr. Vernon Rom
St. Rt. 3, Box 59
Towner, North Dakota 58788

Orlin R. Ouim
SR 2, Box 16
Towner, North Dakota 58788

Alan A. Kramer
Executive Vice President
First Western Bank
P.O. Box 1090
Minot, North Dakota 58701

Jonathon C. Eaton, Jr.
Eaton, Van De Streek and Ward
306 Midwest Federal Building
Minot, North Dakota 58701

Mr. Wally Beyer
Box 277
Velva, North Dakota 58790

Melvin Nelson
Towner, North Dakota 58788

Mr. Bruce Helseth
RR 1, Box 30
Carpio, North Dakota 58725

Cecil Booth
Route 1, Box 16
Velva, North Dakota 58790

E. C. McCarroll
McCarroll Ranch
Tolley, North Dakota 58787

Mr. Jack Miller
M.G.M., Inc.
Mohall, North Dakota 58761

Mr. Allen Gross
M.G.M., Inc.
Mohall, North Dakota 58761

Mr. James Mathiason, President
Citizens State Bank
Mohall, North Dakota 58761

Mr. Glenn Wunderlich
Chairman
Souris River Joint Board
Voltaire, North Dakota 58792

Auditor
City of Landsford
Landsford, North Dakota 58750

Mr. Richard A. Johnson
Co-Chairman
Citizens United to Save the Valleys
P.O. Box 25
Mohall, North Dakota 58761

Mr. David Blocker, Chief
Mohall Fire Department
Mohall, North Dakota 58761

Mr. and Mrs. Don Stewart
Sherwood, North Dakota 58782

J.E. Southham
City Drug Store
Box 158
Mohall, North Dakota 58761

Manager, Farmers Union Oil
Company
Mohall, North Dakota 58761

Mr. Arden Haner
Chairman
Ward County Water Resource Board
Douglas, North Dakota 58735

Board of Commissioners
Ward County Courthouse
315 SE 3rd
Minot, North Dakota 58701

Mayor
City of Sherwood
Sherwood, North Dakota 58782

Mr. James G. Schmidt
Manager, First American Bank and
Trust of Minot/Lansford Station
P.O. Box 147
Lansford, North Dakota 58750

Clerk
Lansford Public School District
#35
Lansford, North Dakota 58750

Minot Area Development Corporation
200 South Broadway
P.O. Box 940
Minot, North Dakota 58702

Minot Chamber of Commerce
200 South Broadway
P.O. Box 940
Minot, North Dakota 58702

Mr. Ivar Johnston
Johnston Chevrolet Co., Inc.
P.O. Box 308
Lansford, North Dakota 58750

Mr. Matt Aberle, President
Mohall Business Promotions
Mohall, North Dakota 58761

Ms. Joyce N. Lunde,
Office Manager, Gate City
Federal Savings and Loan
Main Street, Box 248
Mohall, North Dakota 58761

Renville County Water
Management Board
Mohall, North Dakota 58761

Minot Convention and Visitors
Bureau
200 South Broadway, Box 940
Minot, North Dakota 58702

Commander
91st Strategic Missile Wing (SAC)
Minot Air Force Base, ND 58705

Ms. Clair O. Southam, Secretary
Mohall Improvement, Inc.
Mohall, North Dakota 58761

Ms. Roberta E. Southam, President
Mohall Industrial and Community
Development Corporation
Mohall, North Dakota 58761

State House Department
ATTN: Teri Lunde
Box 5520
Bismarck, North Dakota 58502-5220

The Wildlife Society
North Dakota Chapter
1305 Business Loop East
Jamestown, North Dakota 58401

Ms. Pam Dryer, Coordinator
Natural Resources and Trails
1424 W. Century Avenue, Suite 202
Bismarck, North Dakota 58501

Dr. Fred Schneider
Department of Anthropology
University of North Dakota
Box 8254, University Station
Grand Forks, North Dakota 58202

Mr. Dennis T. Disrud, Ph.D.
Environmental Consultant
413 Hillcrest Drive
Minot, North Dakota 58701

Ms. Mary L. Notbohm
Notbohm Motors, Inc.
127 W. Main
Mohall, North Dakota 58761

Ms. Mary Nell-Redman
Bureau of Reclamation
Technical Support Services
P.O. Box 1017
Bismarck, North Dakota 58501

North Dakota Water Users
P.O. Box 2254
Bismarck, North Dakota 58502

Mr. Francis Schwindt
North Dakota State Health Department
1200 Missouri Avenue
Bismarck, North Dakota 58501-5520

Ms. Patricia Schmidt
Box 112
Velva, North Dakota 58790

Mr. Francis Schwindt
North Dakota State Health Department
1200 Missouri Avenue
Bismarck, North Dakota 58501-5520

Mr. George Hood
Souris Basin Development Authority
814 4th Street
Estevan, Saskatchewan
Canada S4A 0V9

APPENDIX 4

SOURIS BASIN PROJECT
MITIGATION ANALYSIS

TABLE OF CONTENTS

INTRODUCTION

The purpose of this appendix is to present the procedures used to quantify the fish and wildlife impacts of the Souris Basin project and to describe mitigation features proposed for compensation of project-induced habitat losses. The procedure used is based upon a prior mitigation analysis conducted for the Lake Darling four-foot raise project. Many of the impacts associated with the Lake Darling project are identical to those occurring on the Souris Basin project.

The Habitat Evaluation Procedures (FWS, 1980) were used as the framework for quantification of habitat gains and losses. A brief overview follows this introduction. The remainder of the appendix presents a description of the Lake Darling mitigation analysis and a description of how this analysis was modified to obtain the Souris Basin mitigation plan.

HABITAT EVALUATION PROCEDURES

The Habitat Evaluation Procedures (HEP) quantify habitat change using changes in habitat quantity and quality. In a HEP analysis habitat value is measured in "Habitat Units (HU)" which are defined as the product of habitat quantity (acres) and an index of habitat quality (the Habitat Suitability Index or HSI):

$$HU = HSI \times Acres$$

The HSI value ranges from 0.0 (very poor quality habitat) to 1.0 (optimal habitat). HSI values used in the Lake Darling and Souris Basin projects are derived from the habitat requirements of a group of species which are known to use one or more of the habitat types found in the project area.

The overall effect of a project is determined by comparing future with-project to future without-project conditions. Computationally, this process requires the team of project biologists to make projections as to future acreage and HSI values at various intervals (target years) after initiation of project construction. These future conditions are then compared graphically or with a weighted average called "Average Annual Habitat Units" (AAHU).

MITIGATION ANALYSIS - LAKE DARLING PROJECT

The Lake Darling Project mitigation analysis identified several measures which were then proposed to compensate for the adverse environmental effects associated with a four-foot raise of the Lake Darling dam and operation of that dam for flood control at Minot. The analysis and proposed compensation plan were presented in appendix 6 of the Lake Darling EIS (COE, 1986). Although this EIS filed with EPA on 14 February 1986, most of the data collection and data analysis for mitigation planning was

conducted in the mid to late 1970's. A Record of decision for the Lake Darling Four-Foot Raise project including the compensation plan was signed in June 1986.

Quantification of Project Impacts

To quantify project effects it is necessary to determine the quality and quantity of habitat available under existing conditions, future with-project conditions, and future without-project conditions. The following paragraphs describe how these values were determined for the Lake Darling project (note: the same data are used for the Souris Basin project). A description of two errors in the Lake Darling analysis and the effect of these errors is also included.

Habitat types were delineated and acreages were determined using aerial photography and U.S.G.S. topographic maps of the entire Souris River. To facilitate the analysis, the river valley was split into seven impact segments (table 1), each of which was mapped separately.

Field observations by biologists from the Corps of Engineers and Fish and Wildlife Service were used as the basis for assigning habitat quality (HSI) values to the various habitat types within each impact segment. Eight or nine evaluation species were used for each habitat type (table 2) and biologists rated the suitability of the habitat type for each species on a scale of 1 to 10. The HSI for a given habitat type (Table 1) was computed as the sum of the ratings for each of the eight (or nine) species divided by 80 (or 90). It should be noted that HSI values were based on the professional expertise of the project biologists since HSI models were not available at the time the analysis was conducted.

The quality and quantity of habitat available in future years was determined for the with-project and without-project conditions. Without the four foot raise of Lake Darling, habitat quality was assumed to decline while acreages remained unchanged. This projected decline in habitat quality was based on continued wetland drainage, increased use of forested areas for grazing, and intensification of agricultural practices.

Construction of the four foot raise would have resulted in some direct losses of habitat acreage and a decline in habitat quality due to changes in the flood regime. Specifically, lower flood peak flows and longer flow duration associated with the flood control operation plan would have flooded low areas for longer periods of time thereby killing some of the vegetation and affecting the utility of the habitat for many species. Altered flow regimes would have also affected operation of the J. Clark Salyer National Wildlife Refuge (NWR) by disrupting their 5-year management cycle.

To determine HSI values in future years, values for existing conditions were adjusted to reflect the changes in habitat quality which would have resulted from factors just described. Adjustments to the HSI values considered the relationship between duration of inundation and vegetation losses (COE, 1977). A hydrologic model of the J. Clark Salyer NWR was used

Table 1 Lake Darling Baseline Conditions			
Wetland	Segment(1)	Habitat Acres (2)	Habitat Unit Value (HUV)
Wetland	1-2	1,779	.43
	3	1,346	.43
	4-5	805	.43
	6	15,926	.53
	7	20,100	.8
Woodland	1-2	659	.71
	3	157	.71
	4-6	7,731	.71
	7	2,115	.71
Agricultural land	1-2	445	.35
	3	82	.35
	4-6	8,100	.35
	7	350	.35
Grassland	1-2	1,064	.54
	3	20	.54
	4-6	5,708	.54
	7	2,482	.66

(1) Segment 1 - Saskatchewan border to upper end of Lake Darling, Segment 2 - upper end of Lake Darling to Lake Darling Dam, Segment 3 - Lake Darling Dam to Baker Bridge, Segment 4 - Baker Bridge to Burlington Dam, Segment 5 - Burlington Dam to Logan, Segment 6 - Logan to J. Clark Salyer NWR, Segment 7 - J. Clark Salyer NWR.

(2) Segments 1 and 2: up to elevation 1605 in the raised Lake Darling floodpool. Segments 3-7: within the 5,000 ft^3/s flooded outline downstream of the Lake Darling dam.

Table 2: Evaluation Species Used in the Lake Darling Analysis

Wetland	Hardwoods	Grassland	Cultivated Land
White-tailed deer	White-tailed deer	White-tailed deer	White-tailed deer
Red fox	Raccoon	White-tailed jackrabbit	White-tailed jackrabbit
Mink	Beaver	Badger	Red fox
Raccoon	Mink	Red fox	Skunk
Pheasant	Pheasant	Sharp-tailed grouse	Gray partridge
Blue-winged teal	Wood duck	Willit	Mallard
Avocet	Great blue heron	Meadowlark	Franklin's gull
Canvasback	Chickadee		Horned lark
Canada goose			

to determine the effect on refuge management and make appropriate adjustments to the HSI values in impact segment 7. The acreage and HSI values which were used in the Lake Darling impact analysis are summarized in table 3. When used in the HEP procedure, values in this table produce the same quantification of impacts found in the Lake Darling EIS (table 4).

Errors In Lake Darling Analysis - The following errors in the Lake Darling analysis are evident upon careful examination of the values in table 3.

a) Wetland Losses - Segments 1&2: Since the four-foot raise project would have had significant effects on wetlands at the upstream end of Lake Darling, there should be a difference between with and without project HSI values. An examination of the values in table 3 shows that this is not the case, and in fact, future with and without project values are virtually identical. This error occurred when the same vegetation loss rates were used to compute HSI values for both future with and without project conditions. To correct the error, the loss rate under future without-project conditions was changed from 6.3% to 3.5% thereby yielding the corrected values in table 5. The new loss rate was determined based on the vegetation losses associated with various levels of flooding and the probabilities of the different flood magnitudes under without-project conditions.

b) Acreage Losses Due to Construction Activities - According to the HEP manual, acreage and HSI values for target year 0 must be the same under both with and without project conditions. Furthermore, losses occuring during project construction should first appear at target year 1. These conditions were reversed in the Lake Darling analysis where construction losses were reflected in target year 0, but were not carried forward into the future (table 3). To correct the error, with-project values at target year 0 have been changed to be the same as without-project values, and construction impacts have been factored into future target years (table 5).

A reanalysis using corrected inputs (table 5) results in a 21 percent increase (1399 AAHU lost versus 1156 AAHU lost) in the impact of the Lake Darling project (table 6).

Identification of Potential Mitigation Measures

Potential mitigation measures for the Lake Darling four-foot raise project were identified through close consultation with the Fish and Wildlife Service, refuge personnel, and interested citizens and citizen groups. As a result of strong public objection, the congressional authorization for the Lake Darling project directed the Corps to avoid affecting private lands, and therefore identification of mitigation features focused on improving management capabilities on the two National Wildlife Refuges. The potential mitigation features which were identified are described in table 7.

TABLE 3: Acreage and HSI values used in the Lake Darling analysis

WETLANDS

	WITHOUT PROJECT CONDITIONS										WITH PROJECT CONDITIONS									
	SEG 1-2		SEG 3		SEG 4-5		SEG 6		SEG 7		SEG 1-2		SEG 3		SEG 4-5		SEG 6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	1779	0.430	1346	0.430	805	0.430	15926	0.530	20100	0.800	1752	0.430	1346	0.430	801	0.430	15920	0.530	20100	0.800
TY-1	•	0.300	•	0.420	•	0.420	•	0.520	•	•	1779	0.379	•	0.415	805	0.418	15926	0.506	•	0.743
TY-5	•	0.310	•	•	•	•	•	0.510	•	•	•	0.310	•	0.410	•	0.415	•	•	•	0.755
TY-10	•	0.260	•	•	•	•	•	•	•	•	•	0.264	•	•	•	•	•	•	•	0.756
TY-20	•	0.230	•	•	•	•	•	•	•	•	•	0.227	•	•	•	•	•	•	•	•
TY-100	•	0.215	•	•	•	•	•	•	•	•	•	0.215	•	•	•	•	•	•	•	•

WOODLANDS

	WITHOUT PROJECT CONDITIONS								WITH PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7		SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	659	0.710	157	0.710	7731	0.710	2115	0.710	644	0.710	157	0.710	7701	0.710	2115	0.710
TY-1	•	•	•	0.710	•	0.709	•	0.680	659	0.709	•	0.704	7731	0.700	•	0.666
TY-5	•	•	•	0.707	•	•	•	0.670	•	0.706	•	0.700	•	0.707	•	0.650
TY-10	•	0.709	•	•	•	•	•	•	•	0.706	•	•	•	•	•	•
TY-20	•	0.708	•	•	•	•	•	•	•	0.699	•	•	•	•	•	•
TY-100	•	0.700	•	•	•	•	•	•	•	0.683	•	•	•	•	•	•

AGLAND

	WITHOUT PROJECT CONDITIONS								WITH PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7		SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	445	0.350	82	0.350	8100	0.350	350	0.350	445	0.350	82	0.350	8100	0.350	350	0.350
TY-1	•	•	•	0.335	•	0.330	•	0.290	•	0.337	•	0.334	•	0.328	•	0.294
TY-5	•	•	•	0.330	•	0.320	•	0.280	•	0.333	•	0.330	•	0.320	•	0.280
TY-10	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
TY-20	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
TY-100	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

GRASSLAND

	WITHOUT PROJECT CONDITIONS								WITH PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7		SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	1064	0.540	20	0.540	5700	0.540	2482	0.660	1023	0.540	20	0.540	5595	0.540	2482	0.660
TY-1	•	0.530	•	0.519	•	0.520	•	0.606	1064	0.510	•	0.510	5700	0.520	•	0.599
TY-5	•	0.510	•	•	•	0.519	•	0.590	•	0.465	•	0.505	•	0.516	•	0.583
TY-10	•	0.490	•	•	•	0.518	•	•	•	0.425	•	0.504	•	•	•	0.582
TY-20	•	0.470	•	•	•	0.519	•	•	•	0.380	•	•	•	•	•	•
TY-100	•	0.450	•	•	•	•	•	•	•	0.343	•	•	•	•	•	•

Table 4: Impacts (in AAHU) of the Lake Darling Project Using the Values in Table 3

Habitat/Segment	AAHU with project	AAHU without project	AAHU change
Wetland seg 1 and 2	415.39	417.35	-1.97
Wetland seg 3	552.16	565.39	-13.22
Wetland seg 4 and 5	334.19	338.14	-3.95
Wetland seg 6	8,060.45	8,127.83	-67.38
Wetland seg 7	15,202.58	16,080.00	-877.41
Woodland seg 1 and 2	457.12	464.61	-7.49
Woodland seg 3	109.92	111.01	-1.09
Woodland seg 4-6	5,466.02	5,481.32	-15.30
Woodland seg 7	1,386.23	1,418.00	-31.77
Agricultural land seg 1 and 2	148.27	155.75	-7.48
Agricultural land seg 3	27.08	27.08	0.00
Agricultural land seg 4-6	2,594.83	2,595.24	-0.41
Agricultural land seg 7	98.24	98.21	0.04
Grassland seg 1 and 2	400.43	497.05	-96.61
Grassland seg 3	10.09	10.38	-0.29
Grassland seg 4-6	2,946.28	2,962.77	-16.48
Grassland seg 7	1,448.66	1,466.24	-17.58
Total AAHU change			-1,156.39

The distribution of habitat unit losses by area is as follows: Upper Souris Refuge - 11.4 percent; private lands - 9.2 percent; and J. Clark Salyer - 79.5 percent.

To maintain the continued pool management capabilities and levels of productivity in the refuges, structural modifications that would avoid adverse impact on management capabilities and production levels are included as project features.

TABLE 5: Corrected acreage and HSI values used in a reanalysis of the Lake Darling project (circled values identify changes in the original Lake Darling analysis -- Table 3).

WETLANDS

	WITHOUT PROJECT CONDITIONS									
	SEG 1-2		SEG 3		SEG 4-5		SEG 6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	1779	0.430	1346	0.430	805	0.430	15926	0.530	20100	0.800
TY-1	•	0.415	•	0.420	•	0.420	•	0.520	•	•
TY-5	•	0.368	•	•	•	•	•	0.510	•	•
TY-10	•	0.332	•	•	•	•	•	•	•	•
TY-20	•	0.297	•	•	•	•	•	•	•	•
TY-100	•	0.279	•	•	•	•	•	•	•	•

	WITH PROJECT CONDITIONS									
	SEG 1-2		SEG 3		SEG 4-5		SEG 6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	1779	0.430	1346	0.430	805	0.430	15926	0.530	20100	0.800
TY-1	1752	0.379	•	0.415	801	0.418	15920	0.506	•	0.743
TY-5	•	0.310	•	0.410	•	0.415	•	•	•	0.755
TY-10	•	0.264	•	•	•	•	•	•	•	0.756
TY-20	•	0.227	•	•	•	•	•	•	•	•
TY-100	•	0.215	•	•	•	•	•	•	•	•

WOODLANDS

	WITHOUT PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	659	0.710	157	0.710	7731	0.710	2115	0.710
TY-1	•	•	•	0.710	•	0.709	•	0.680
TY-5	•	•	•	0.707	•	•	•	0.670
TY-10	•	0.709	•	•	•	•	•	•
TY-20	•	0.708	•	•	•	•	•	•
TY-100	•	0.700	•	•	•	•	•	•

	WITH PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	659	0.710	157	0.710	7731	0.710	2115	0.710
TY-1	644	0.709	•	0.704	7701	0.708	•	0.666
TY-5	•	0.706	•	0.700	•	0.707	•	0.650
TY-10	•	0.706	•	•	•	•	•	•
TY-20	•	0.699	•	•	•	•	•	•
TY-100	•	0.683	•	•	•	•	•	•

AGLAND

	WITHOUT PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	445	0.350	82	0.350	8100	0.350	350	0.350
TY-1	•	•	•	0.335	•	0.330	•	0.290
TY-5	•	•	•	0.330	•	0.320	•	0.280
TY-10	•	•	•	•	•	•	•	•
TY-20	•	•	•	•	•	•	•	•
TY-100	•	•	•	•	•	•	•	•

	WITH PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	445	0.350	82	0.350	8100	0.350	350	0.350
TY-1	•	0.337	•	0.334	•	0.328	•	0.294
TY-5	•	0.333	•	0.330	•	0.320	•	0.280
TY-10	•	•	•	•	•	•	•	•
TY-20	•	•	•	•	•	•	•	•
TY-100	•	•	•	•	•	•	•	•

GRASSLAND

	WITHOUT PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	1064	0.540	20	0.540	5700	0.540	2482	0.660
TY-1	•	0.530	•	0.519	•	0.520	•	0.606
TY-5	•	0.510	•	•	•	0.519	•	0.590
TY-10	•	0.490	•	•	•	0.518	•	•
TY-20	•	0.470	•	•	•	0.519	•	•
TY-100	•	0.450	•	•	•	•	•	•

	WITH PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	1064	0.540	20	0.540	5700	0.540	2482	0.660
TY-1	1023	0.510	•	0.510	5595	0.520	•	0.599
TY-5	•	0.465	•	0.505	•	0.516	•	0.583
TY-10	•	0.425	•	0.504	•	•	•	0.582
TY-20	•	0.300	•	•	•	•	•	•
TY-100	•	0.343	•	•	•	•	•	•

Table 6: Reanalysis of Impacts of the Lake Darling Project Using Corrected Inputs from Table 5

ID	Species Name	AAHU with project	AAHU without project	AAHU change
1	Wetland seg 1 & 2	409.14	532.34	-123.15
2	Wetland seg 3	552.16	565.39	-13.22
3	Wetland sseg 4 & 5	332.54	338.14	-5.60
4	Wetland seg 6	8,057.43	8,127.83	-70.39
5	Wetland seg 7	15,192.58	16,080.00	-887.41
6	Woodland seg 1 & 2	446.77	464.61	-17.79
7	Woodland seg 3	109.92	111.01	-1.09
8	Woodland seg 4-6	5,444.92	5,481.32	-36.30
9	Woodland seg 7	1,386.23	1,418.00	-31.77
10	Agland seg 1 & 2	148.27	155.75	-7.48
11	Agland seg 3	27.08	27.08	0.00
12	Agland seg 4-6	2,594.83	2,595.24	-0.41
13	Agland seg 7	98.24	98.21	0.04
14	Grassland seg 1 & 2	385.11	497.05	-111.83
15	Grassland seg 3	10.09	10.38	-0.29
16	Grassland seg 4-6	2,888.25	2,962.77	-74.21
17	Grassland seg 7	1,448.66	1,466.24	-17.58
			TOTAL	-1,398.49

Table 7: Summary of Mitigation Features Proposed for the Lake Darling Project.

Feature	Description
Conduit to 96A&B	Construct conduit from pond C to pool 96A which would provide a consistent water supply for management of pools 96A and 96B (Benefits: 113 AAHU*; Costs: $460,000**)
Conduit to pool 87	Construct conduit from Lake Darling on the east side of the valley to pool 87 thereby providing a consistent water supply for management of the pool. (Benefits: 86 AAHU; Costs: $1,900,000**)
Raise Dams 326, 332, and 341	Raise these dams by 1 foot to maintain vegetation management capabilities. (Benefits: 863 AAHU; Cost: $985,100***)
Lowflow Conduit at dam 320	Construct conduit through the west end of dam 320 to provide water and improve management capabilities at the upper end of pool 326. (Benefits: 25 AAHU; Cost: $17,900)
Pothole Construction	Construct 20 pothole wetlands in the wet meadow area of pool 320. (Benefits: 26 AAHU; Cost: $403,000)
Salyer Division	Construct an 11-mile diversion from the upper end of pool 320, around pools 326 and 332, to the upper end of pool 341. The diversion would be designed to either pass 650 cfs around the pools or to deliver any portion of the water back into pools 326 or 332 through stop-log structures. (Benefits: 1800 AAHU; Cost: $3,985,000**)

* Subsequent to the Lake Darling study, detailed engineering analysis indicated that only half of the projected benefits (56 of 113 AAHU) would be realized because water could not be delivered to pools 96A and B without some disruption of management capabilities on ponds A, B, and C.

** These costs are preliminary estimates made during the Lake Darling study. Other costs are based on more recent detailed design work.

*** Costs for dam raises are actually greater, however the additional cost is attributed to dam safety rather than mitigation benefits.

In order to quantify the benefits of potential mitigation measures, the acres affected by a given measure are multiplied by the change in HSI which is expected to occur. For the Lake Darling project, acreages were readily determined from maps and aerial photographs. Anticipated changes in the HSI values were based on the professional opinion of refuge managers who were asked to estimate the increase in productivity attributable to a given mitigation feature and the time period necessary to realize the increased productivity (table 7 summarizes the expected benefit of the mitigation measures).

Selection of a Compensation Plan

A compensation plan was developed from the list of potential mitigation features described above. Although other factors were considered, the basic goal in selecting a compensation plan is to provide an acceptable amount of compensation for the lowest possible cost. The process used to screen mitigation features while comparing their costs and benefits is termed "incremental analysis".

Five potential compensation options were identified by the Lake Darling study team (table 8). Each option was comprised of a mix of the mitigation features identified in table 7. To compare the options, the features within each option were ordered from those with lowest cost per AAHU gain, to those with highest cost per AAHU gain (table 9). For each compensation option the cumulative costs and gains for each additional feature included in the option were determined and plotted (Figure 1). This "incremental analysis" enables a comparison of the relative efficiency of the compensation options and the features within each option.

A study of figure 1 reveals that options 4 and 5 dramatically exceed mitigation needs and are much more costly than other options. Options 1, 2, and 3 do not meet mitigation needs although option 3 comes closer than the other two. One other factor apparent in figure 1 is that elimination of the conduit to pool 87 from option 3 would save almost 2 million dollars while losing only 8% of total mitigation benefits.

Option 3 was selected as the recommended compensation plan for the Lake Darling Project. The conduit to pool 87 was retained in this plan because the 8% mitigation it provided was considered important since option 3 still did not provide 100 percent compensation.

TABLE 8
CORRECTED
LAKE DARLING
SUMMARY IMPACT TABLE
OPTION COMPARISON

REFUGE FEATURES	AAHU LOST	OPTION 1 AAHU GAIN	OPTION 1 COST(K)	OPTION 2 AAHU GAIN	OPTION 2 COST(K)	OPTION 3 AAHU GAIN	OPTION 3 COST(K)	OPTION 4 AAHU GAIN	OPTION 4 COST(K)	OPTION 5 AAHU GAIN	OPTION 5 COST(K)
UPPER SOURIS NWR	261										
1a) CONDUIT TO 96A&B		113	460	113	460	113	460	113	460	113	460
1b) CONDUIT TO POOL 87				86	1900	86	1900			86	1900
PRIVATE LAND	249										
J. CLARK SALYER NWR											
2) RAISE DAM 326	890	437	483	437	483	437	483				
3) RAISE DAM 332		206	252	206	252	206	252				
4) RAISE DAM 341						220	251				
5) LOWFLOW CONDUIT @320		25	18	25	18	25	18	25	18	25	18
6) POTHOLE CONSTRUCTION		26	403	26	403	26	403				
8) SALYER DIVERSION	132							1800	3985	1800	3985
TOTAL	1399	807	1615	893	3515	1113	3766	1938	4463	2024	6363

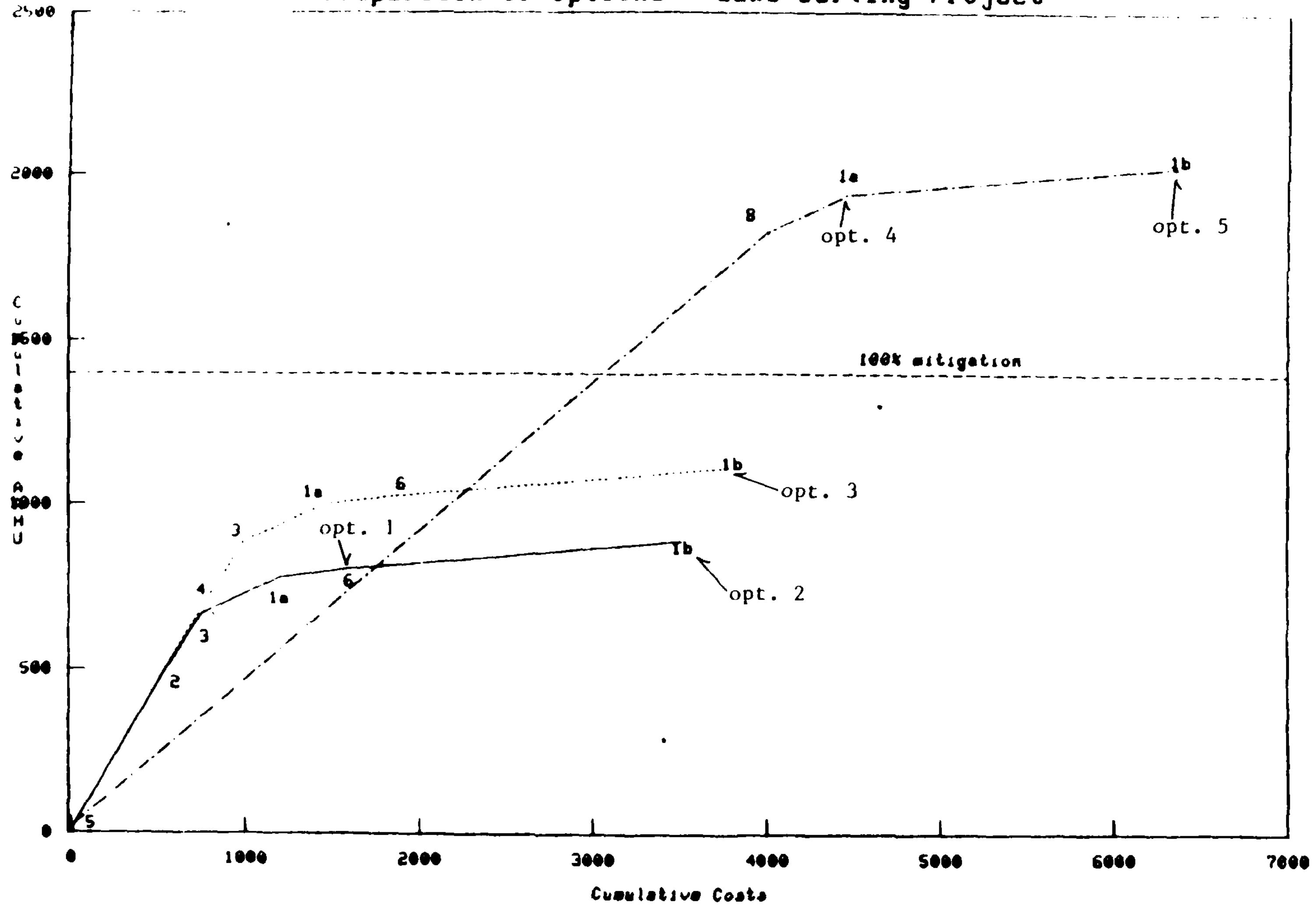
Actual costs for dam raises are greater than reflected in this table, however the additional cost is attributed to dam safety rather than mitigation benefits.

Table 9: Mitigation options for the Lake Darling project. Features within each option are ranked according to cost per total HU gain. The options are plotted in Figure 1.

Feature	Cost per Total HU*	Cumulative Cost (K)	Cumulative AAHU
OPTION 1:			
5) Lowflow conduit at 320	7.16	17.9	25
2) Raise Dam 326	11.04	500.4	462
3) Raise Dam 332	12.21	752.0	668
1a) Conduit to 96A & B	88.46	1212.0	781
6) Pothole construction	155.00	1615.0	807
OPTION 2:			
All features from option 1	-	1615.0	807
1b) Conduit to pool 87	220.93	3515.0	893
OPTION 3:			
5) Lowflow conduit at 320	7.16	17.9	25
2) Raise Dam 326	11.04	500.4	462
4) Raise Dam 341	11.41	751.4	682
3) Raise Dam 332	12.21	1003.0	888
1a) Conduit to 96A & B	88.46	1463.0	1001
6) Pothole construction	155.00	1866.0	1027
1b) Conduit to 87	220.93	3766.0	1113
OPTION 4:			
5) Lowflow conduit at 320	7.16	17.9	25
8) Salyer Diversion	22.14	4002.9	1825
1a) Conduit to 96A & B	88.46	4462.9	1938
OPTION 5:			
All features from option 4	-	4462.9	1938
1b) Conduit to pool 87	220.93	6362.9	2024

* Total Habitat Units are the total number of habitat units produced over the entire 100-year project life. They are computed by multiplying the number of AAHU by 100.

Figure 1:
Comparison of Options - Lake Darling Project



(Number symbols refer to features identified in table 8.)

MITIGATION ANALYSIS - SOURIS BASIN PROJECT

Differences between the impacts associated with the Lake Darling project and those associated with the Souris Basin project are discussed in detail in Section 5.00 of this EIS and are summarized below:

a. The Souris Basin project would have reduced impact upstream of Lake Darling due to elimination of the four foot raise.

b. The Souris Basin project would result in fewer vegetation losses around Lake Darling dam due to smaller scale construction activities.

c. The Souris Basin project would cause conversion of an estimated 1000 acres of floodplain land to urban uses as a result of protection from the 100-year flood.

d. The Souris Basin project would extend the duration of 500 cfs releases from Lake Darling during control of large floods (50 and 100-year events).

In addition to the specific differences in impacts, the Souris Basin project assumes a different future without-project condition. The Lake Darling project assumed only minor deviations from existing conditions throughout the life of the project. The Souris Basin project assumes several changes including construction of water supply dams in Canada and associated changes in water quality and quantity (see section 4.70 in this EIS).

In a normal situation new future without-project habitat quality (HSI) values would be developed for use in the HEP analysis. In this instance time was not available to conduct the studies necessary to develop new HSI values. The choice was then to subjectively estimate new values or to use the future without-project habitat values from the Lake Darling analysis. It was decided to use the Lake Darling values for the following reasons:

a. The difference between the Souris Basin and the Lake Darling future without-project HSI values is expected to be relatively small (less than 0.1 HSI) in most instances.

b. The increment of impact attributable to the effects of flood operation is expected to be relatively constant within the expected range of future without-project habitat values.

c. Subjectively estimating new future without-project habitat values for the Souris Basin project without the benefit of further study would be no more than a guess.

The following paragraphs describe the quantification of project effects, the identification and quantification of project mitigation features, and selection of a recommended mitigation plan for the project.

Quantification of Project Impacts

The corrected HEP analysis for the Lake Darling project (tables 5 and 6) is used as a basis for quantification of the impacts of the Souris Basin project. The following changes were made in the Lake Darling HSI and acreage values to reflect the different impacts of the Souris Basin project (refer to table 10).

a. Impact Segments 1 & 2 - The Lake Darling project would have affected 1779 acres of wetland, 659 acres of woodland, 445 acres of agricultural land, and 1064 acres of grassland in impact segments 1 and 2. Since the Souris Basin project would directly affect only 15 acres of wetland and result in quality changes on another 200 wetland acres in impact segments 1 and 2, the following adjustments were made:

	Wetland	Woodland	Agland	Grassland
LAKE DARLING ANALYSIS				
Without proj. (all targ. yrs)	1779	659	445	1064
With proj.				
targ. year 0	1779	659	445	1064
other targ yrs.	1752	644	445	1023
SOURIS BASIN ANALYSIS				
Without proj. (all targ. yrs)	215	0	0	0
With proj.				
targ. year 0	215	0	0	0
other targ yrs.	200	0	0	0

b. Impact Segments 4-6 - Provision of protection from large floods would result in conversion of an estimated 1000 acres of agricultural land to urban use over the 100-year life of the project. The acreage of agricultural land in this reach is therefore decreased by 10 acres per year to reflect this change.

The modifications just described do not include any consideration of the effects of the prolonged 500 cfs releases during large floods. As discussed in the EIS (see paragraph 5.62), the primary impacts of these prolonged releases would be to cause vegetation losses in flooded areas. Attempts to quantitatively address the effects of prolonged releases by modifying the HSI values were not successful because this HEP analysis is extremely sensitive to small changes in HSI values and therefore predicts unrealistically high losses (tables 12 and 13).

The HSI and acreage values in table 10 are used to quantify the impacts of the proposed Souris Basin project. Because these values do not include the effects of the prolonged 500 cfs releases, this analysis underestimates the impact of the project. Note that the quantified impacts of the Souris

TABLE 10: Acreage and HSI values used in the Souris Basin analysis (circled values represent changes in the corrected Lake Darling analysis -- Table 5).

WETLANDS

WITHOUT PROJECT CONDITIONS

	SEG 1-2		SEG 3		SEG 4-5		SEG 6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	215	0.430	1346	0.430	805	0.430	15926	0.530	20100	0.800
TY-1	•	0.415	•	0.420	•	0.420	•	0.520	•	•
TY-5	•	0.368	•	•	•	•	•	0.510	•	•
TY-10	•	0.332	•	•	•	•	•	•	•	•
TY-20	•	0.297	•	•	•	•	•	•	•	•
TY-100	•	0.279	•	•	•	•	•	•	•	•

WITH PROJECT CONDITIONS

	SEG 1-2		SEG 3		SEG 4-5		SEG 6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	215	0.430	1346	0.430	805	0.430	15926	0.530	20100	0.800
TY-1	200	0.379	•	0.415	801	0.418	15920	0.506	•	0.743
TY-5	•	0.310	•	0.410	•	0.415	•	•	•	0.755
TY-10	•	0.264	•	•	•	•	•	•	•	0.756
TY-20	•	0.227	•	•	•	•	•	•	•	•
TY-100	•	0.215	•	•	•	•	•	•	•	•

WOODLANDS

WITHOUT PROJECT CONDITIONS

	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.710	157	0.710	7731	0.710	2115	0.710
TY-1	•	•	•	0.710	•	0.709	•	0.680
TY-5	•	•	•	0.707	•	•	•	0.670
TY-10	•	0.709	•	•	•	•	•	•
TY-20	•	0.708	•	•	•	•	•	•
TY-100	•	0.700	•	•	•	•	•	•

WITH PROJECT CONDITIONS

	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.710	157	0.710	7731	0.710	2115	0.710
TY-1	•	0.709	•	0.704	7701	0.708	•	0.666
TY-5	•	0.706	•	0.708	•	0.707	•	0.650
TY-10	•	0.706	•	•	•	•	•	•
TY-20	•	0.699	•	•	•	•	•	•
TY-100	•	0.683	•	•	•	•	•	•

AGLAND

WITHOUT PROJECT CONDITIONS

	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.350	82	0.350	8100	0.350	350	0.350
TY-1	•	•	•	0.335	•	0.330	•	0.290
TY-5	•	•	•	0.330	•	0.320	•	0.280
TY-10	•	•	•	•	•	•	•	•
TY-20	•	•	•	•	•	•	•	•
TY-100	•	•	•	•	•	•	•	•

WITH PROJECT CONDITIONS

	SEG 1-2		SEG 3		SEG ·-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.350	82	0.350	8100	0.350	350	0.350
TY-1	•	0.337	•	0.334	8090	0.328	•	0.294
TY-5	•	0.333	•	0.330	8050	0.320	•	0.280
TY-10	•	•	•	•	8000	•	•	•
TY-20	•	•	•	•	7900	•	•	•
TY-100	•	•	•	•	7100	•	•	•

GRASSLAND

WITHOUT PROJECT CONDITIONS

	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.540	20	0.540	5700	0.540	2482	0.660
TY-1	•	0.530	•	0.519	•	0.520	•	0.606
TY-5	•	0.510	•	•	•	0.519	•	0.590
TY-10	•	0.490	•	•	•	0.518	•	•
TY-20	•	0.470	•	•	•	0.519	•	•
TY-100	•	0.450	•	•	•	•	•	•

WITH PROJECT CONDITIONS

	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.540	20	0.540	5700	0.540	2482	0.660
TY-1	•	0.510	•	0.510	5595	0.520	•	0.599
TY-5	•	0.465	•	0.505	•	0.516	•	0.583
TY-10	•	0.425	•	0.504	•	•	•	0.582
TY-20	•	0.380	•	•	•	•	•	•
TY-100	•	0.343	•	•	•	•	•	•

Table 11: Impacts (in AAHU) of the Souris Basin Project Using Inputs from Table 10.

ID	Species Name	AAHU with project	AAHU without project	AAHU change
1	Wetland seg 1 & 2	46.70	64.34	-17.60
2	Wetland seg 3	552.16	565.39	-13.22
3	Wetland seg 4 & 5	332.54	338.14	-5.60
4	Wetland seg 6	8,057.43	8,127.83	-70.39
5	Wetland seg 7	15,192.58	16,080.00	-887.41
6	Woodland seg 1 & 2	0.00	0.00	0.00
7	Woodland seg 3	109.92	111.01	-1.09
8	Woodland seg 4-6	5,444.92	5,481.32	-36.30
9	Woodland seg 7	1,386.23	1,418.00	-31.77
10	Agland seg 1 & 2	0.00	0.00	0.00
11	Agland seg 3	27.08	27.08	0.00
12	Agland seg 4-6	2,420.43	2,595.24	-174.81
13	Agland seg 7	98.24	98.21	0.04
14	Grassland seg 1 & 2	0.00	0.00	0.00
15	Grassland seg 3	10.09	10.38	-0.29
16	Grassland seg 4-6	2,888.25	2,962.77	-74.21
17	Grassland seg 7	1,448.66	1,466.24	-17.58
			TOTAL	-1,330.25

TABLE 12: Acreage and HSI values used to quantify the effect of prolonged 500 cfs releases (circled values represent changes in the values used in the Souris Basin analysis -- Table 10).

WETLANDS

	WITHOUT PROJECT CONDITIONS									
	SEG 1-2		SEG 3		SEG 4-5		SEG 6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	215	0.430	1346	0.430	805	0.430	15926	0.530	20100	0.800
TY-1	"	0.415	"	0.420	"	0.420	"	0.520	"	"
TY-5	"	0.368	"	"	"	"	"	0.510	"	"
TY-10	"	0.332	"	"	"	"	"	"	"	"
TY-20	"	0.297	"	"	"	"	"	"	"	"
TY-100	"	0.279	"	"	"	"	"	"	"	"

	WITH PROJECT CONDITIONS									
	SEG 1-2		SEG 3		SEG 4-5		SEG 6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	215	0.430	1346	0.430	805	0.430	15926	0.530	20100	0.800
TY-1	200	0.379	"	0.415	801	0.418	15920	0.497	"	0.720
TY-5	"	0.310	"	0.410	"	0.415	"	0.448	"	0.609
TY-10	"	0.264	"	"	"	"	"	"	"	"
TY-20	"	0.227	"	"	"	"	"	"	"	"
TY-100	"	0.215	"	"	"	"	"	"	"	"

WOODLANDS

	WITHOUT PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.710	157	0.710	7731	0.710	2115	0.710
TY-1	"	"	"	0.710	"	0.709	"	0.680
TY-5	"	"	"	0.707	"	"	"	0.670
TY-10	"	0.709	"	"	"	"	"	"
TY-20	"	0.708	"	"	"	"	"	"
TY-100	"	0.708	"	"	"	"	"	"

	WITH PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.710	157	0.710	7731	0.710	2115	0.710
TY-1	"	0.709	"	0.704	7701	0.693	"	0.639
TY-5	"	0.706	"	0.700	"	0.663	"	0.524
TY-10	"	0.706	"	"	"	"	"	"
TY-20	"	0.699	"	"	"	"	"	"
TY-100	"	0.683	"	"	"	"	"	"

AGLAND

	WITHOUT PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.350	82	0.350	8100	0.350	350	0.350
TY-1	"	"	"	0.335	"	0.330	"	0.290
TY-5	"	"	"	0.330	"	0.320	"	0.280
TY-10	"	"	"	"	"	"	"	"
TY-20	"	"	"	"	"	"	"	"
TY-100	"	"	"	"	"	"	"	"

	WITH PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.350	82	9.350	8100	0.350	350	0.350
TY-1	"	0.337	"	0.334	8090	0.323	"	0.289
TY-5	"	0.333	"	0.330	8050	0.316	"	0.275
TY-10	"	"	"	"	8000	"	"	"
TY-20	"	"	"	"	7900	"	"	"
TY-100	"	"	"	"	7100	"	"	"

GRASSLAND

	WITHOUT PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	0.0	0.540	20	0.540	5700	0.540	2482	0.660
TY-1	"	0.530	"	0.519	"	0.520	"	0.606
TY-5	"	0.510	"	"	"	0.519	"	0.590
TY-10	"	0.490	"	"	"	0.518	"	"
TY-20		0.470	"	"	"	0.519	"	"
TY-100		0.450	"	"	"	"	"	"

	WITH PROJECT CONDITIONS							
	SEG 1-2		SEG 3		SEG 4-6		SEG 7	
	ACRES	HSI	ACRES	HSI	ACRES	HSI	ACRES	HSI
TY-0	1064	0.540	20	0.540	5700	0.540	2482	0.660
TY-1	1023	0.510	"	0.510	5595	0.506	"	0.569
TY-5	"	0.465	"	0.505	"	0.453	"	0.445
TY-10	"	0.425	"	0.504	"	"	"	"
TY-20	"	0.380	"	"	"	"		"
TY-100	"	0.343	"	"	"	"		

Table 13: Impacts of the Souris Basin Project when effects of the prolonged 500 cfs flows are included (impact determinations are based on the values in table 12).

ID	Species Name	AAHU with project	AAHU without project	AAHU change
1	Wetland seg 1 & 2	46.70	64.34	-17.60
2	Wetland seg 3	552.16	565.39	-13.22
3	Wetland seg 4 & 5	332.54	338.14	-5.60
4	Wetland seg 6	7,158.19	8,127.83	-969.63
5	Wetland seg 7	12,315.87	16,080.00	-3,764.13
6	Woodland seg 1 & 2	0.00	0.00	0.00
7	Woodland seg 3	109.92	111.01	-1.09
8	Woodland seg 4-6	5,113.35	5,481.32	-367.86
9	Woodland seg 7	1,116.31	1,418.00	-301.69
10	Agland seg 1 & 2	0.00	0.00	0.00
11	Agland seg 3	27.08	27.08	0.00
12	Agland seg 4-6	2,390.17	2,595.24	-205.07
13	Agland seg 7	96.50	98.21	-1.71
14	Grassland seg 1 & 2	0.00	0.00	0.00
15	Grassland seg 3	10.09	10.38	-0.29
16	Grassland seg 4-6	2,544.38	2,962.77	-418.09
17	Grassland seg 7	1,114.85	1,466.24	-351.39
			TOTAL	-6,417.37

Basin project (table 11) are not much less than those of the Lake Darling project (1330 AAHU versus 1399 AAHU).

Identification of Potential Mitigation Measures

Potential mitigation features considered for the Souris Basin project are identical to those considered for the Lake Darling project (table 7) with the following exceptions:

a. Water Supply to Pools 87, 96 A & B - Engineering work conducted subsequent to publication of the Lake Darling Final EIS has indicated that the proposed water supply conduit to pools 96 A & B would not provide the benefits claimed in the initial analysis. To supply water to pool 96A would require ponds A, B, and C to be filled to their maximum level. Operation of these ponds at full levels would degrade their habitat values and, as a result, habitat unit benefits from the conduit to 96A would decrease from the projected 113 AAHU to 52 AAHU.

   To remedy this situation and to provide the benefits claimed in the Lake Darling analysis, this mitigation feature was redesigned so that the water supply conduit to pool 87 is located on the west side of the valley instead of the east side. This alternative design enables direct delivery of water to pond A, pond B, pond C, pool 87, and pool 96A, thereby increasing habitat benefits (300 AAHU versus 138 AAHU).

b. Salyer Diversion - Construction of a diversion channel around several of the pools in the J. Clark Salyer NWR was not considered as a potential mitigation feature in the Souris Basin analysis. This feature was eliminated because of strong opposition by refuge personnel. Their primary objections include the following:

   a. The diversion would only be used on an infrequent basis (approximately 15 times in 100 years).

   b. Construction of the diversion would require commitment of 186 acres of land including 62 acres of wetland.

   c. Pools 341 and 357 would be subject to increased nutrient loading because of direct (unfiltered through other pools) input of river water. Experience has shown tnat those pools with highest nutrient load are more susceptible to avian disease problems later in the season.

   d. The channel may be a barrier to wildlife movement when it is carrying water.

   e. The diversion channel and associated structures would have to be maintained by refuge personnel.

c. Riprap of Nesting Islands - In addition to the features considered for the Lake Darling mitigation analysis, the costs and benefits of providing erosion protection for nesting islands in the J. Clark Salyer NWR were considered as part of the Souris Basin mitigation analysis. Approximately 30 percent of the duck production and 15 percent of the goose production for the entire refuge takes place on the nesting islands. These islands also provide valuable brood rearing habitat, loafing areas, and protective cover for molting waterfowl. The nesting islands are eroding from wave action during periods of high water. The potential mitigation feature calls for protection of the islands through placement of riprap on areas of erosion.

The Fish and Wildlife Service also suggested one additional feature for consideration in developing a mitigation plan for the Souris Basin project. This feature called for establishment of an operation and maintenance fund to compensate for unforeseen impacts such as potential for increased avian disease problems in the Salyer refuge, unforeseen erosion problems, and potential increases in the frequency of waterfowl overwintering. The operation and maintenance fund was not considered in the mitigation analysis because most of these potential impacts would either be very infrequent (e.g. waterfowl overwintering) or would be very difficult to attribute to the proposed action (e.g. changes in the frequency of avian disease problems).

Selection of a Compensation Plan

As with development of the Lake Darling compensation plan, a basic goal in selecting a plan for the Souris Basin project is to provide an acceptable amount of mitigation for the lowest possible cost. Four potential options for mitigating the adverse effects of the Souris Basin project were identified (table 14). All of these options include raising three dams and construction of a low flow conduit on J Clark Salyer NWR. These features have a high benefit - cost ratio because a lot of work on the dams is already required for flood control operational purposes (e.g. installation of heaters and actuators).

Following the same procedures outlined for the Lake Darling incremental analysis, the features within each option were ranked according to cost per AAHU gain (table 15) and are compared graphically (Figure 2). The three features with highest cost per habitat unit were analyzed to determine if the benefits were worth the costs:

a. Riprap of Nesting Islands - This feature would protect 19 nesting islands from erosion at a cost of 1.8 million dollars. On a per island basis this translates into almost $100,000 for each island protected. Ducks Unlimited builds a lot of nesting islands in North Dakota and estimates that it costs approximately $25,000 to build a 1-acre island. Since protection of the islands would cost almost four times the cost of building new islands, this feature was not felt to be incrementally justified and was not included in the proposed compensation plan.

TABLE 14
SOURIS BASIN
SUMMARY IMPACT TABLE
OPTION COMPARISON

REFUGE FEATURES	AAHU LOST	OPTION 1 AAHU GAIN	OPTION 1 COST(K)	OPTION 2 AAHU GAIN	OPTION 2 COST(K)	OPTION 3 AAHU GAIN	OPTION 3 COST(K)	OPTION 4 AAHU GAIN	OPTION 4 COST(K)
UPPER SOURIS NWR	18								
1) CONDUIT TO A,B,C,96A&B,87				300	3995	300	3995	300	3995
PRIVATE LAND	435								
J. CLARK SALYER NW.									
2) RAISE DAM 326	890	437	483	437	483	437	483	437	483
3) RAISE DAM 332		206	252	206	252	206	252	206	252
4) RAISE DAM 341		220	251	220	251	220	251	220	251
5) LOWFLOW CONDUIT @320		25	18	25	18	25	18	25	18
6) POTHOLE CONSTRUCTION						26	403	26	403
7) RIPRAP ISLANDS								31	1798
TOTAL	1343	888	1003	1188	4998	1214	5401	1245	7199

Actual costs for dam raises are greater than reflected in this table, however the additional cost is attributed to dam safety rather than mitigation benefits.

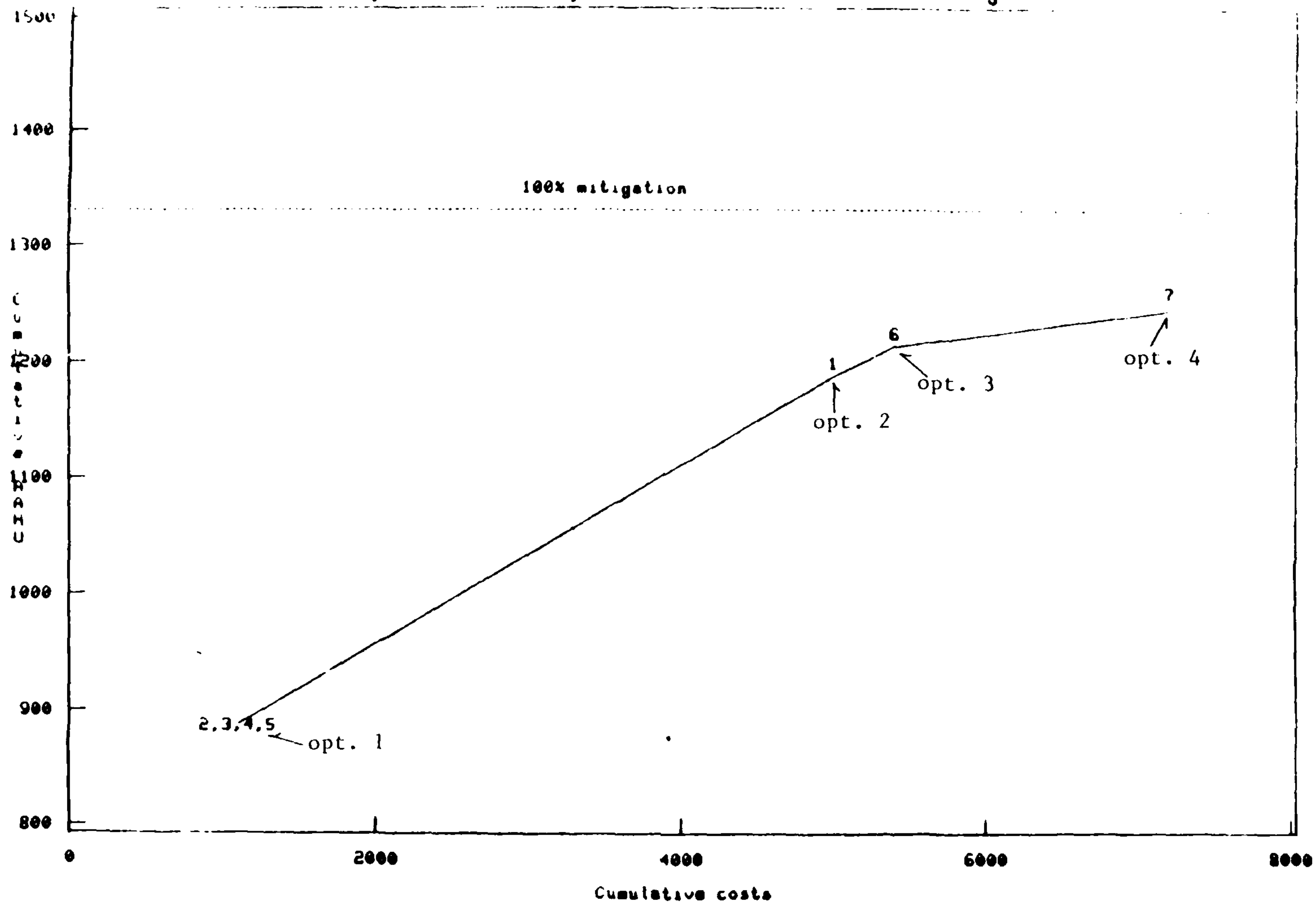
Table 15: Mitigation options for the Souris Basin project. Features within each option are ranked according to cost per AAHU gain. The options are plotted in Figure 2.

Feature	Cost per AAHU*	Cumulative Cost (K)	Cumulative AAHU	Cumulative % Comp.**
OPTION 1:				
5) Lowflow conduit at 320	7.16	17.9	25	1.9
2) Raise Dam 326	11.04	500.4	462	34.7
4) Raise Dam 341	11.41	751.4	682	51.3
3) Raise Dam 332	12.21	1003.0	888	66.8
OPTION 2:				
All features from option 1	-	1003.0	888	66.8
1) Combined conduit to 96 and 87	133.17	4998.0	1188	89.3
OPTION 3:				
All features from option 2	-	4998.0	1188	89.3
6) Pothole constuction	155.00	5401.0	1214	91.3
OPTION 4:				
All features from option 3	-	5401.0	1214	91.3
7) Riprap nest islands	580.00	7199.0	1245	93.6

* Total Habitat Units are the total number of habitat units produced over the entire 100-year project life. They are computed by multiplying the number of AAHU by 100.

** Percentages are based on quantified impacts only. The effects of prolonged 500 cfs releases and the evaporation sharing agreement could not be quantified given existing data.

Figure 2:
Comparison of Options - Souris Basin Project



(Number symbols refer to features identified in table 14.)

b. Pothole Construction - The proposed potholes would be 0.5 to 1 acre in size and would cost an average of over $20,000 each. Strict quantitative analysis of the incremental feasibility of this option was not possible since the increase in duck or waterbird populations attributable to the potholes could not be determined. Although quantitative analysis was not feasible, it was felt that the habitat benefits were not worth the cost on a per bird basis. Since this feature represents only a small portion of the total mitigation package (2%) and since the incremental justification is questionable, the feature was not included in the proposed compensation plan.

c. Conduit to Pools A, B, C, 96 A&B, 87 - This feature is the most costly of all features considered and as a result was closely examined in the incremental analysis. Once again, quantitative analysis was not possible, however the water supply conduit is included in the proposed compensation plan for the following (qualitative) reasons:

   - The conduit would dramatically improve the management capabilities on the Upper Souris NWR.
   - A very large amount of habitat (933 acres) would benefit from the water supply conduit.
   - Waterfowl production is expected to increase substantially.
   - The populations of other waterbirds and associated predators species are also expected to benefit.
   - Deletion of this feature would result in an unacceptably low level of compensation for project impacts (67%).

The incremental analysis concluded that option 2 is the most justifiable plan and is therefore proposed as the compensation plan for the Souris Basin project. Option 2 compensates for 89% of the quantifiable losses and includes raising dams 326, 332, and 341, construction of a low-flow structure at dam 320, and construction of a water supply conduit to ponds A, B, and C, pool 87, and pools 96 A & B.

RELATIONSHIP TO MITIGATION POLICIES

Current Corps of Engineers (COE) mitigation policy provides eight basic directions which pertain to development of a plan to mitigate for the impacts of the Souris Basin project. These directions are summarized below with a description of how the recommended plan complies with policy directives.

a. Habitat Based Evaluation - The evaluation procedure used to determine mitigation needs is to be based upon accepted habitat-based evaluation methods.

   The recommended plan is based upon the 1976 version of the Habitat Evaluation Procedures which was the best evaluation method available at the time the field work was conducted.

b. Incremental Justification - The most cost-effective features for mitigating impacts should be given priority consideration; that is, the last increment of losses prevented should exceed the added costs of the last increment of mitigation.

An incremental analyses of each potential option and the features within each option was an important step in recommending a mitigation plan (refer to "Plan Selection", above).

c. Project Lands - Mitigation measures should be provided on project lands to the extent practicable and justifiable.

The recommended mitigation plan meets the intent of this directive by providing mitigation features on the National Wildlife Refuges as opposed to recommending the purchase of separable lands to meet mitigation needs.

d. Contiguous Lands - To the extent practicable, mitigation measures should be contiguous to the areas where impacts occur.

The impacts of the Souris Basin project would occur along the entire length of the river. It is therefore appropriate that the recommended mitigation plan focuses on improving river resources along the upstream and downstream portions of the river. It is not economically practicable to propose a wider geographical spread to the mitigation features.

e. Use of Public Lands - Non-Federal public lands already being managed for environmental purposes will not be acquired for mitigation.

The recommended mitigation plan does not require any land purchase.

f. Beneficial Effects - The extent to which the beneficial fish and wildlife actions associated with the project offset adverse impacts should be assessed before considering separable measures.

There are no quantifiable beneficial fish and wildlife effects associated with the Souris Basin Project.

g. Consideration of Separable Measures - Separable measures should be evaluated when adverse effects exceed the beneficial impacts associated with the project.

The Habitat Evaluation Procedures provide a standard method for evaluating the tradeoffs between the positive benefits and adverse effects associated with a project. The HEP analyses of the Souris Basin project indicates that net adverse effects would result.

h. In-Kind Mitigation - To the extent practicable, losses in a given habitat type will be offset by mitigation measures which replace or raise the value of the same type of habitat.

The majority of the adverse impacts associated with the Souris Basin project occur in woodland and wetland habitat types. Most of the recommended mitigation measures are directed at improving wetland areas which results in a net loss of woodland habitat and a net gain in wetland habitat. Replacement of woodland losses would require purchase of separable land because there are no areas on the National Wildlife Refuges which could reasonably be converted to woodland habitat. The tradeoff of woodland for wetland is acceptable to the Fish and Wildlife Service and is justified because purchase of separable land is contrary to congressional directive for this project.

SUMMARY

Mitigation needs for the Souris Basin project were quantified using the Habitat Evaluation Procedures and data from a previous HEP analysis of the Lake Darling project. When reanalyzing the Lake Darling data, two computational mistakes were found which, when corrected, indicated the impacts of the Lake Darling project had been underestimated by 21 percent.

Two quantitative differences between the Souris Basin and Lake Darling projects were identified and used as a basis for modifying the Lake Darling analysis:

a. In the area upstream of the Lake Darling dam the Souris Basin project would affect only 215 wetland acres whereas the Lake Darling project would have affected 1779 wetland acres, 659 woodland acres, 445 acres of agland, and 106 acres of grassland.

b. Due to protection from the 100-year flood, the Souris basin project would result in the urbanization of an estimated 1000 acres of agricultural land over the life of the project.

A HEP analysis conducted using corrected Lake Darling data adjusted for the impacts of the Souris Basin project indicates that quantifiable habitat losses would be slightly less with the Souris Basin project (1330 AAHU for the Souris Basin project versus 1399 AAHU for the Lake Darling project). Impacts associated with the prolonged 500 cfs releases could not be quantified, hence the HEP analysis underestimates the impacts of the project.

The recommended mitigation plan for the Souris Basin project includes many of the same features as the Lake Darling project:

Souris Basin Mitigation Plan	Lake Darling Mitigation Plan
Benefits: 1188 AAHU (89%)	Benefits: 1052 AAHU (79%)
Cost: $5.0 million	Cost: $3.4 million
Features:	Features:
- Water supply conduit to ponds A,B,C, pool 96 A & B, and pool 87 (west side location)	- Water supply conduit to pool 87 (east side location)
	- Conduit from pond C to 96 A
- Upgrade dams 326, 332, 341	- Upgrade dams 326, 332, 341
- Low flow structure at dam 320	- Low flow structure at dam 320
	- Construct pothole wetlands

Although the recommended plan appears to mitigate for 89% of the project effects, it actually provides less mitigation due to impacts which could not be quantified. For this reason it is not recommended that any features be deleted from the proposed compensation plan.

LITERATURE CITED

Corps of Engineers, 1986. Final Feature Environmental Impact Statement, Lake Darling Flood Control Project. St. Paul District.

Corps of Engineers, 1977. Assessment of Habitat Damages Due to Flooding: A Proposed Methodology. St. Paul District.
(Note: This methodology has been used in assessing the impacts of projects in Sheyenne, North Dakota; Twin Valley, Minnesota; and LaFarge, Wisconsin)

U.S. Fish and Wildlife Service, 1980. Habitat Evaluation Procedures (HEP). Division of Ecological Services, ESM 102.

APPENDIX 5

Recreation Sites

APPENDIX 5
Recreation Sites

Boat Landings 1, 2, and 3 - The U.S. Fish and Wildlife Service refuge office operates and maintains three boat landings immediately above the Lake Darling Dam. Landing 1, on the west shore of Lake Darling about 150 yards north of the dam, services both lake and shore fishermen. Like other Fish and Wildlife Service landings, this site provides limited picnicking opportunities, parking, and toilet facilities in support of a boat ramp. This site receives an average of about 10 percent of refuge use.

Landings 2 and 3 are also on the west shore of the lake, about one-half mile above landing 1. Landing 2 receives about 8 percent of the refuge use. The landing has toilet facilities and a gravel surfaced boat ramp. Landing 3 is more popular, receiving from 15 to 30 percent of annual refuge use. The site has toilet facilities, two concrete surface launching lanes, a water well, fireplaces, and picnic tables.

Grano Bridge Ramp - Located east of the Grano Bridge, this site is used for boat launching and bank fishing. In addition to a gravel ramp, the site includes a comfort station and picnic tables.

Greene Crossing Park - Greene Crossing is a 5-acre park west and south of Mohall on State Highway 28 where it crosses Lake Darling. Like the other landings, this site is used for bankfishing and related picnicking, in addition to boat launching. Recorded use at this site has increased over the last several years to about 13 to 14 percent of annual refuge use.

Outlet Fishing Area - This day-use site consists of a picnic area, two parking areas, a well, and toilet facilities. It is immediately downstream of the Lake Darling spillway.

Renville County Park - Renville County Park is a 70-acre recreation area on the Upper Souris River about 18 miles west of Mohall, North Dakota and 25 miles east of Kenmare, North Dakota. It is an important recreational resources for a four county area of north central North Dakota.

The park departs from most outdoor recreation areas in north central North Dakota because of the private cabins and lots that abut the county-owned public recreation area. Two-hundred and four privately-owned lots are listed by the county assessor. However, many of the lots do not include permanent structures.

These lots generally surround the public recreation area and its picnic and camping facilities, ballfields, playground equipment and four group use structures. From May to October a concessionaire operates a cafe, bar, roller rink and meeting/dance hall at the publicly-owned park.

The park serves as a summer meeting place for residents of four counties. In recent years the park has been the scene of organizational picnics, school reunions, ball tournaments and other special events. The event that

attracts the largest number of people is the Old Settlers Picnic which is held annually each summer.

Grano Park (Crossing) - Grano Park is on the east shore of Lake Darling. Facilities at this 45-acre site consist of a parking lot, boat ramp, picnic tables, vault toilets, and camping pads. The Renville County Park Board operates and maintains the site, which accounts for approximately 20 to 25 percent of total refuge area recreation use. Previous Corps studies have shown that this site is heavily used by fishermen for access to one of the two areas in Lake Darling open for boat fishing.

Bridge Recreation Sites - Two bridge crossings, Baker Bridge, and St. Mary's Bridge are popular sites for bank fishing and picnicking. Baker Bridge is 15 miles north of Minot on Ward County Road 15 where it crosses the Souris River. St. Mary's Bridge, also called Silver Bridge, is 2 miles upstream from Baker Bridge. Each site has toilet facilities and parking areas delineated with wood post bollards.

Souris Valley Golf Course - This 18-hole municipal golf course is managed by the Minot Park Board. It is located along the banks of the Souris River. Only half of the course is usable for recreation when flows reach 3000 cfs. With flows of 5000 cfs or more the course is closed to public use. Flooding results in revenue loss and high restoration costs for removal of flood-deposited silt. Bank erosion has also been identified by the park board as a problem which threatens adjacent fairways and greens.

APPENDIX 6

Significant Cultural Sites

APPENDIX 6

Significant Cultural Sites

National Register Properties:

McKinney Cemetery (32RV101) - The McKinney Cemetery was established in the 1880's and includes the gravesites of many of the area's pioneers. Although the cemetery was associated with the former townsite of McKinney, the cemetery is still being used by the local residents. This property has been placed on the National Register of Historic Places because of its age and significance to local history.

National Register Eligible Properties:

Site 32RV15 - This prehistoric archeological site was located during the 1982 survey of the project area above Lake Darling. It is an occupation site in the Souris River floodplain. A total of 333 items were recovered during testing. Much of the material is unidentifiable bone fragments recovered from a single formal test unit, however, a number of lithic artifacts were recovered, including a projectile point identified as a Paskapoo type. This projectile point is similar to others identified in Saskatchewan, Canada, dating from A.D. 1350 to A.D. 1773. In addition to the artifacts recovered from the site, an ash lens with burned bone and firecracked rock represent a hearth feature.

Site 32RV415 - This site was originally located during the 1977 survey of Burlington Dam and was relocated during the 1982 survey of Lake Darling. The site, located above Lake Darling, was tested during the 1984 field season. The site is a stratified prehistoric occupation site that has been assigned to the Plains Village Manifestation of the Late Woodland Period based upon diagnostic artifacts. Testing at the site reveals at least two intact components beneath the plow zone. Materials recovered from the site include ceramics (n=136), lithics (n=64), bone (n=64), and enough charcoal for carbon-14 dating. One of the pieces of bone had been altered by grooving.

Site 32RV420 - This prehistoric site was located along the west shore of Lake Darling by the University of North Dakota during the 1977 field season. The site is a stone circle (tipi ring) site consisting of 11 definite rings approximately 3.1 to 5.4 meters in diameter. Only 10 of the rings could be relocated in 1983 when the site was tested. Testing at the site revealed intact subsurface deposits of cultural material. Over 260 items of bone and stone were recovered from the test units. Two distinct components, stratigraphically separated were identified at the site. The large number of identified remains were associated with a buried component at the site. Little cultural material was actually found associated with the rings.

Site 32RV421 - This prehistoric site was discovered during the 1977 field season. Four single-course, stone circles of a Plains Nomadic cultural affiliation were located along the west shoreline of Lake Darling. The

stone appeared disturbed and the number of circles were difficult to discern. During the 1983 testing of this site, six circles were located. Two activity loci were found within the site; one with a concentration of Swan River chert and the other with a predominance of Knife River flint. No diagnostic artifacts were recovered from the site, and no material other than lithic material was recovered from any of the test units.

Site 32RV422 - This prehistoric archeological site was recorded by the University of North Dakota during the 1977 field season. Six single-course circles of Plains Nomadic affiliation cover 3 acres adjacent to Highway 28 on the west side of Lake Darling. Additional circles may have been destroyed during the construction of Highway 28. The intact portion of the site is in good condition and the circles are easily discernible. Circle diameters range from 4.3 to 6.6 meters, and most have 50 or more stones per circle. A total of 86 artifacts were recovered from this site, with 91% (77) coming from one of the test units. All of the recovered material was lithic, none of which was diagnostic.

Site 32RV429 - Located during the 1977 survey, this prehistoric site represents one of the most concentrated cultural sites in the upper portion of the project area. Cultural material located in private collections and that recovered during survey and testing indicate a long span of occupation for this site. Cultural material dates from the Early Archaic Period through the proto-historic and historic periods. Ceramic analysis identified material from both the Extended Middle Missouri Variant and the Late Woodland cultures of southern Saskatchewan and Manitoba. Significant, intact, cultural deposits are buried well below the plow zone at this site, including identified features.

Site 32RV23 (Syverson Homestead) - This abandoned farmstead located above Lake Darling was homesteaded by Ole Syverson in 1904. A two-story dwelling and a one-story dwelling of frame construction are located on the property along with several farm outbuildings. The two-story frame dwelling was built from plans ordered through Sears-Roebuck, and it is the only verifiable mail-order house known within the survey area.

Site 32RV431 (Parker Log House) - The parker Log House along with a smaller guesthouse and a smokehouse is now part of the Eckert Ranch. The house and guesthouse, located on the east shore of Lake Darling, are constructed of square-cut pine logs brought from Washington State. The smokehouse is of native fieldstone. Both the main house and guesthouse have gabled roofs with large overhangs on the eaves and gabled ends. The structures were built in 1924 by Minot businessman Clarence Parker as a retreat and party place during prohibition.

Site 32RV437 (Swenson Cabin) - This structure is a two-pen log dwelling constructed (above Lake Darling) by a man named Toverson. A 1940's frame addition was constructed by the Swensons who occupied the structure until 1968. The structure has a gabled roof with a shed roof over the addition. Exterior log walls are roughly hewn and dove-tail joined at the corners. It is likely that this structure is the only remaining original log structure upstream of Minot that dates to the early ranching era.

Site 32RV440 (Brekkas Stone House) - This property consists of a two-story, quarry-finished, fieldstone dwelling and associated outbuildings. the structure was built in 1904 after the original homestead was destroyed in the spring flood of 1904. A wood-frame addition was added to the house in 1909. The addition was the Barber, North Dakota general store; the last functioning business of the Barber townsite. The Brekkas Stone House is of interest because the motifs and arches are features seldom found in the area's vernacular architecture.

Site 32RV441 (Mouse River Park/Renville County Park) - This site, located above Lake Darling, is a recreational and meeting area established in 1911. The site was first platted in October 1912, and lots were sold beginning in January of the following year. In August 1913, the site was purchased by the Mouse River Chautauqua Association, which held summer educational and religious meetings there. An auditorium and dance hall was built in 1914, followed by a store, restaurant, bathhouses, and barn in 1917. Madam Shuman Heink, Billy Sunday, William Jennings Bryan, and many State politicians spoke at the park, and an early Lawrence Welk band played at the dance pavilion. The park continues to be an important site for political, religious, social, and recreational activities.

APPENDIX 7

Lake Darling Section 404(b)(1) Evaluation

SECTION 404(b)(1) EVALUATION
LAKE DARLING DAM AND ASSOCIATED FEATURES
SOURIS RIVER, NORTH DAKOTA

I. PROJECT DESCRIPTION

A. Location - The proposed fill activity would take place in the Souris River, within the Upper Souris and J. Clark Salyer National Wildlife Refuges (NWR) in North Dakota.

B. General Description - The proposed fill activities would consist of the following:

Upper Souris NWR

1. A 4-foot raise of the Lake Darling Dam.

2. Riprapping at Grano Crossing, Soo Line Railroad, State Highway 5, and State Highway 28.

3. Levee and high-flow cutoff channel at Renville County Park.

4. Levee and outlet structure at McKinney Cemetery.

5. Stepped drop channel and levee at Eckert Ranch.

6. Riprapped and stabilized spillway and embankment at dam 41.

7. Construction of a conduit to pond A.

8. Construction of new fishing facilities downstream of Lake Darling Dam.

9. Raise of the boat-launching facilities within the Upper Souris NWR.

10. Rehabilitation and riprapping of the gated structure at dam 96.

11. Construction of a water supply channel from Lake Darling Dam to pool 87.

12. Construction of a levee and outlet structure around pool 87.

13. Construction of an outlet structure from pond A.

14. Construction of a water supply conduit from pond C to pools 96 A and B.

J. Clark Salyer NWR

15. Construction of a carp control structure downstream of dam 357.

16. Raise service roads, scenic trails, and boat-launching facilities.

17. A 2-foot raise in dam 326, dam 332, and dam 341.

18. Construction of a low-flow structure at dam 320.

Other Features

19. Burlington to Minot subdivision levees.

a. Johnson's Addition.

b. Brooks' Addition.

c. Talbot's Nursery.

d. Country Club Acres and Robinwood Estates.

e. King's Court and Rostad's Addition.

f. Tierrecito Vallejo.

20. Sawyer levee.

C. Authority and Purpose - Federal authority for this project is in the 1982 Energy and Water Development Appropriations Act, Public Law 97-88, approved December 4, 1981. The purpose of the project is to provide flood protection along the Souris River.

D. General Description of Dredged or Fill Material

1. General Characteristics of Material - In all cases, the fill material would be clean, pervious and impervious random fill, rock riprap, and concrete.

2. Quantity of Material - The fill material would consist of the following quantities for the specific actions proposed.

	Activity	Quantity of Fill (CY)
Upper Souris NWR		
	a. Lake Darling Dam	720,000
	b. Grano Crossing	75,000
	c. Soo Line Railroad	125,000
	d. State Highway 28	75,000
	e. State Highway 5	20,000
	f. Levee and high-flow cutoff channel	4,000
	g. Stepped drop channel and levee	4,000
	h. Spillway and embankment stabilization	7,000
	i. Raise service roads	80,000
	j. Conduit to pond A	5,000
	k. New fishing facilities	20,000

	l. Raise boat-launching facilities	10,000
	m. Upgrade gated structure at dam 96	400
	n. Outlet structure from pond A	50
	o. Outlet and conduit from pond C	17,000
	p. Water supply to pool 87	100
	q. Levee around pool 87	15,000
J. Clark Salyer NWR		
	a. Carp control structure	73,000
	b. Raise facilities	71,000
	c. Raise dam 326	92,000
	d. Raise dam 332	62,000
	e. Raise dam 341	33,000
	f. Low-flow structure at dam 320	50
Other Features		
	a. Johnson's Addition	24,000
	b. Brooks' Addition	45,000
	c. Talbot's Nursery	6,000
	d. Country Club Acres and Robinwood Estates	40,000
	e. King's Court and Rostad's Addition	21,000
	f. Tierrecito Vallejo	20,000
	g. Sawyer levee	25,000

3. Source of Material - The rock and fill material would be obtained from approved quarries and borrow sites in the vicinity of the project.

E. Description of the Proposed Discharge Sites

1. Location - The proposed fill activities would take place along the Souris River, in North Dakota. The Upper Souris NWR is approximately 20 miles upstream of Minot, North Dakota, and is on the upstream end of the United States portion of the Souris River loop. The J. Clark Salyer NWR is on the lower portion of the loop, approximately one-half mile upstream of where the river re-enters Canada.

2. Size - The proposed action would directly affect approximately 95 acres of habitat. This effect would include a loss of approximately 40 acres of wetlands and 45 acres of riparian woodlands.

3. Type of Site -The fill activities would take place in the following site types: riverine, lake, wetland, and existing levee, dam, and road locations.

4. Types of Habitat -The fill activities would take place in a variety of habitat types, including riverine, persistent and non-persistent palustrine, littoral, and limnetic lacustrine wetlands.

5. Timing and Duration - Subject to approval, construction of the Lake Darling Dam would begin in November 1986. The project would be completed in June 1990 when the downstream improvements would be finished.

F. Description of Disposal Method - Heavy machinery would be used to excavate, transport, and place all fill material.

II. FACTUAL DETERMINATIONS

A. Physical Substrate Determinations

1. Substrate Elevation and Slope - The substrate at the fill sites varies from the existing river bottom to the adjacent riparian banks. It includes the substrates adjacent to existing dams, embankments, and roadways. The slope of the existing stream channel is approximately 0.5 foot per mile whereas the areas adjacent to existing dams and road crossings are virtually flat. The proposed fill activities would increase the stability of structures. The slope and elevation of the river would not be significantly changed by the placement of the fill materials.

2. Sediment Type - Sediments in the proposed fill areas consist of clay, silt, sand, and organic materials with occasional rocks. The proposed activities would require the excavation of this material and replacement with suitable compacted foundation material (rock, sand, and clay). Excavation and placement of fill material would destroy invertebrate habitat. The placement of riprap, however, would create some invertebrate habitat, increasing the diversity in those areas.

3. Dredged/Fill Material Movement - The rock fill material would be sufficiently large and the current velocity would be sufficiently low during construction to preclude movement of the fill material. However, the unarmored levee to be constructed in pool 87 would be subjected to erosive action and would require occasional repair with new material. This eroded material would move into and down the river, slightly increasing the sediment load.

4. Physical Effects on Benthos - Benthic organisms in the areas to be excavated would be eliminated. Benthic habitat would be created and diversity increased in the areas where riprap is placed. The creation of backwater and marsh areas at Renville County Park, pool 87, and pools 96 A and B would significantly increase the amount and quality of benthic habitat.

5. Actions Taken to Minimize Impacts - Adverse impacts resulting from the construction of the proposed project would be compensated for by the construction of several fish and wildlife features (see Lake Darling feature environmental impact statement (EIS) and the Lake Darling general design memorandum supplement No. 3). These features would mitigate for 99 percent of all project-related impacts, including those from the placement of fill material.

B. Water Circulation, Fluctuation, and Salinity Determinations

1. Water

a. Salinity - No appreciable impact would be realized.

b. Water Chemistry - The use of clean fill material and mechanical placement procedures would preclude any significant impacts on the area's water chemistry.

c. Clarity - Some minor, short-term decreases in clarity are expected from the proposed fill activities. The long-term effect from fill placement should be a slight improvement in water clarity.

d. Color - The proposed fill activities should have no impact on water color.

e. Odor - The proposed fill activities should have no impact on water odor.

f. Taste - The proposed fill activities should have no impact on water taste.

g. Dissolved Gas Levels - The proposed fill activities should have no significant impact on dissolved gas levels in the water.

h. Nutrients - The proposed fill activities should have no significant impact on nutrient levels in the water.

i. Eutrophication - The proposed fill activities at Renville County Park would result in the diversion of flows down a high-flow channel. Loss of regular flow would result in the eutrophication of the isolated old channel area. However, a small flow would be maintained to prevent an anaerobic condition from developing. For a detailed discussion of the water quality impacts of the project on the Lake Darling Reservoir, see the EIS.

j. Temperature - The proposed fill activities would have no significant impact on water temperature.

2. Current Patterns and Circulation

a. Current Patterns and Flow - The proposed project would result in the diversion of river flows around the section of river at Renville County Park, a relocation of the Lake Darling outlet structure from the western end of the dam to the eastern end of the structure, the removal of dam 87, and the construction of a levee that would isolate pool 87 from river flows. The long-term impacts of these actions would be beneficial compared to the existing conditions.

b. Velocity - The proposed fill activities (raise of the Lake Darling Dam) would result in extended discharges at higher velocities than are currently realized downstream of the existing structure. The extended duration of higher flows is expected to increase the rate of erosion throughout the Souris River loop.

c. Stratification - The proposed fill activities would have no effect on the development of stratified conditions in the river.

d. Hydrologic Regime - The proposed fill activities would change the existing operating plan for the Lake Darling Dam and Reservoir. This plan would result in the following operating plan. The discharge from the reservoir would be held at 5,000 cfs until May 15 or until elevation 1600 is reached, whichever is later. At that point, the discharge would be reduced to 2,500 cfs. This flow would be maintained until June 1, when the flow would be reduced to 500 cfs. This flow would be maintained until the conservation pool elevation of 1596 is reached. Adverse impacts resulting from the implementation of this plan have been compensated for in the project mitigation plan.

3. Normal Water-Level Fluctuations - The proposed fill activities would result in a 4-foot increase in the flood pool elevation in the reservoir and an extended duration of high flow discharges from the dam (see previous section). Adverse impacts of these effects have been fully compensated for in the project mitigation plan.

4. Salinity Gradient - Not applicable.

5. Actions Taken to Minimize Impact - The reservoir operating plan is the result of intense coordination between the Fish and Wildlife Service, State and local concerns, and Corps of Engineers experts. This plan is viewed as the best compromise between maximizing flood control benefits and minimizing environmental impacts.

C. Suspended Particulate/Turbidity Determination - In all cases, except the levee around pool 87, the fill material would be armored with a suitable size riprap to prevent any erosion and associated resuspension of fill material. There would be some erosion along the pool 87 levee, resulting in resuspension of material and slight increases in turbidity. However, no significant increase in turbidity or in the concentration of suspended particulates are anticipated.

D. Contaminant Determinations - The fill material would be clean fill and rock that would not introduce contaminants into the aquatic system. Neither the material nor its placement would cause any relocation or increase of contaminants in the aquatic system.

E. Aquatic Ecosystem and Organism Determinations

1. Effects on Plankton - Increases in turbidity and suspended solids near the fill activities would have a localized suppressing effect on phytoplankton and zooplankton productivity. However, these local effects are not considered significant when compared to the productivity of the Souris River as a whole. The plankton populations should recover quickly once the fill and other construction activities have ceased, especially since the predominant algae present are pollution-tolerant species.

2. Effects on Benthos - Those benthic communities in the area of the proposed fill activities (placement of riprap, dam construction, etc.) would be eliminated. However, immigration of benthic organisms would occur,

and the areas would be recolonized. In some cases, the diversity of habitat would increase because of the placement of rock riprap, resulting in a local increase in the diversity of the benthic community. Overall impacts on the benthic community should be positive with the construction and implementation of the project mitigation plan (see the EIS). Features included to increase the manageability of the two FWS refuges would optimize the production of the benthic community and consequently of waterfowl.

3. Effects on Fish - Fishery populations in the area of the fill activities are not expected to be significantly affected by the placement of fill material (see the EIS). The primary impact of the project would be the construction of a structure, at the downstream end of the J. Clark Salyer NWR, preventing the upstream movement of carp. This structure would be a combined low-flow electrical barrier and a high-flow velocity barrier. Invasion of carp into the two refuges would significantly reduce the overall habitat value within those areas.

4. Effects on the Aquatic Food Web - The long-term effect on total productivity of the area is expected to be minor, although there would be a temporary disruption to the aquatic biota present and slight changes in localized community structure and composition.

5. Effects on Special Aquatic Sites - Two FWS refuges would be affected by the proposed fill activities. The refuges, the Upper Souris NWR and the J. Clark Salyer NWR, would experience significant adverse effects from the construction of the project. However, these effects would be totally compensated for by the implementation of the mitigation plan (see the EIS, mitigation report (appendix 6), and Fish and Wildlife Coordination Act report (appendix 2)).

6. Threatened and Endangered Species - The proposed activities would have no significant impact on threatened and endangered species.

7. Other Wildlife - The general diversity and productivity of the affected areas would be maintained by the construction of mitigation features within both of the FWS refuges (see the EIS).

8. Actions Taken to Minimize Impact - Construction of refuge operational features and project mitigation features would offset 99 percent of the adverse impacts resulting from the project (see the mitigation report (appendix 6), EIS, and GDM supplement No. 3).

F. Proposed Disposal Site Determinations

1. Mixing Zone Determination - The proposed fill activity would have a minimal mixing zone. The fill would be sufficiently large so that very little of the exposed material could be suspended in the water column. Additionally, at the time the fill would be placed, the river would be at a low flow and would have a correspondingly low carrying capacity. For these reasons, no further analysis of the mixing zone was made.

2. Determination of Compliance with Applicable Water Quality Standards - Any work done in the Souris River must maintain water quality equal to or above the North Dakota State standards. The rock fill material would be obtained from approved pits and quarries, which should insure that State water quality standards would not be violated because of project-related activities.

3. Potential Effects on Human-Use Characteristics - Because of the present and projected human-use characteristics, the existing physical conditions, the proposed construction methods, and the clean nature of the fill material, the proposed fill activities would not have a significant effect on human-use characteristics.

G. Determination of Cumulative Effects on the Aquatic Ecosystem - Implementation of the proposed action would have significant adverse impacts on the aquatic ecosystem of the Souris River. These effects would be mitigated by the implementation of a mitigation plan designed to offset 99 percent of the project impacts (see the mitigation report and EIS).

H. Determination of Secondary Effects on the Aquatic Ecosystem - Significant secondary effects would be mitigated by the implementation of the project mitigation plan (see mitigation report and EIS).

III. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE:

A. Compliance with Section 404(b)(1) Guidelines (Clean Water Act) - The proposed fill activity would comply with the Section 404(b)(1) guidelines of the Clean Water Act. The placement of fill is required to construct the proposed Lake Darling Dam and associated project features. Evaluation of other alternatives has shown that they are either too costly and/or result in an unacceptable level of impacts. (A more detailed analysis of the alternatives is in the EIS.)

B. Compliance with State Water Quality Standards, Section 307 of the Clean Water Act, and Endangered Species Act - The proposed fill activities would comply with all State of North Dakota water quality standards, Section 307 of the Clean Water Act, and the Endangered Species Act of 1973, as amended. The proposed activity would have no adverse impacts on human health or welfare. Plankton, benthic organisms, fish, and bank-dwelling wildlife would be disrupted because of the following factors: burial of existing aquatic habitat, change in current circulation patterns and velocity, change of physical substrate, and increased turbidity and suspended particulates during construction. However, the adverse impacts would be mitigated by the project mitigation plan. There should not be any significant adverse effects on recreational values, aesthetics, and economic values of the area.

C. Steps to Minimize Potential Adverse Effects - Unavoidable adverse impacts resulting from the proposed fill activities would be mitigated by the implementation of the fish and wildlife mitigation plan. This plan would provide 99-percent compensation for the adverse impacts.

D. Determination of Compliance with the Guidelines for the Discharge of Fill Material - On the basis of this evaluation, I have determined that the proposed disposal activities comply with the requirements of the guidelines for the discharge of fill material.

27 Nov. 1985
Date

Joseph Briggs
Joseph Briggs
Colonel, Corps of Engineers
District Engineer

EP-TN/LCSS

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
1135 U. S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101-1479

REPLY TO
ATTENTION OF:

October 25, 1985

Engineering
Project Management

Mr. Dennis Fewless
Water Supply and Pollution
Control Division
North Dakota State Department
of Health
1200 Missouri Avenue
Bismarck, North Dakota 58505

Dear Mr. Fewless:

Pursuant to Section 401 of the Clean Water Act, as amended, I request a State water quality certificate for the Lake Darling flood control project on the Souris River, North Dakota.

I am enclosing a copy of the DEIS (draft feature environmental impact statement) which includes a Section 404(b)(1) evaluation and a discussion of water quality impacts of the project. The DEIS also has served as the public notice for the Section 404(b)(1) requirements. We received no requests for a public hearing.

If you have any questions on the above request, please contact Mr. Barry Drazkowski at 612-725-7771. Your prompt attention to this matter will be appreciated.

Sincerely,

Joseph Briggs
Colonel, Corps of Engineers
District Engineer

1 Enclosure
DEIS, Lake Darling

NORTH DAKOTA
STATE DEPARTMENT OF HEALTH
State Capitol
Bismarck, North Dakota 58505

ENVIRONMENTAL HEALTH SECTION

1200 Missouri Avenue
Box 5520
Bismarck, North Dakota 58502-5520

November 21, 1985

Colonel Joseph Briggs
U.S. Army Corps of Engineers
District Engineer
1135 U.S. Post Office & Custom House
St. Paul, MN 55101-1479

Dear Colonel:

This Department has reviewed the Draft Feature Environmental Impact Statement Flood Control Project, Lake Darling Dam, Souris River, North Dakota, July 1985.

Pursuant to Section 401 of the Clean Water Act, this Department certifies that no state water quality violations will occur if the construction and environmental disturbance specifications of the North Dakota State Department of Health (enclosed) are strictly adhered to.

This Department is concerned about two aspects of the proposed project which could exacerbate current water quality problems. The first is increased shoreline erosion on Lake Darling. The Corps of Engineers should develop a plan to identify and subsequently correct areas which will contribute excessively to sedimentation/turbidity.

The other area of concern is the Corps of Engineers projection on thermal regime. Although the CE-THERM-R1 model predicts weak/temporary thermal stratification, there does remain an increased probability that thermal stratification could be prolonged. If this were to occur, the impact on the ecological matrix of Lake Darling would be profound. The Corps of Engineers should develop a contingency plan addressing this possibility.

Sincerely,

Michael T. Sauer
Limnologist
Water Supply & Pollution Control

MTS:dn
Enc.

Environmental Enforcement 701-224-3234 | Environmental Engineering 701-224-2348 | Environmental Sanitation 701-224-2382 | Hazardous Waste Management & Special Studies 701-224-2386 | Water Supply & Pollution Control 701-224-2354

Construction and Environmental Disturbance Specifications

The following guidelines represent the minimum requirements of the North Dakota State Department of Health to insure the absence of or that minimal environmental degradation occurs as a result of construction or related work which can or will have the potential to affect the waters of the state of North Dakota. All activities will be designed and implemented to restrict the losses or disturbances of soil, vegetative cover, and pollutants (chemical, physical or biological) from the site.

Soils

Prevent erosion of exposed soil surfaces including but not restricted to wind and water erosion by inhibiting the movement of exposed particles and trapping sediments being transported.

Examples Include

Sediment dams and berm, diversion dikes, hay bales as erosion checks, rip-rap, mesh or burlap blankets to hold soil during construction, and immediately establishing vegetative cover on disturbed areas after construction is completed.

Sensitive Flora and Terrain

Fragile and sensitive areas such as wetlands, delicate flora or land resources will be protected against compaction, vegetation loss, and unnecessary damage of these resources.

Surface Waters

All development and construction either directly or indirectly having impacts on aquatic systems will be managed to minimize these impacts. Stream bank and stream bed erosion and disturbances will be controlled to minimize and/or prevent silt movement, nutrient upsurges, plant dislocation and any physical, chemical or biological disruption of an aquatic system. The use of pesticides or herbicides in or near these systems is forbidden without permission.

Prevent the contamination of water at construction sites from fuel spillage, lubricants and chemicals.

Fill Material

All fill material placed below the ordinary high water mark must be free of persistent synthetic organic compounds, decomposable materials, and top soils. The Department may require certification of fill materials. All temporary fills must be removed. Debris and solid wastes will be removed from the site and impacted areas restored as nearly as possible to the original condition.

APPENDIX 8

Endangered Species Coordination

TELEPHONE OR VERBAL CONVERSATION RECORD For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office		DATE 23 February 1987
SUBJECT OF CONVERSATION Section 7 (End Sp. Act) Requirements on the Souris Project		
	INCOMING CALL	
PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
PERSON CALLED	OFFICE	PHONE NUMBER AND EXTENSION
	OUTGOING CALL	
PERSON CALLING John Kittelson	OFFICE Environmental Res. Br., St. Paul District, Corps of Engrs.	PHONE NUMBER AND EXTENSION 725-5985
PERSON CALLED Wally Jobman	ADDRESS Grand Island Field Office U.S. FWS Grand Fal. NE	PHONE NUMBER AND EXTENSION FTS 541-6571

SUMMARY OF CONVERSATION:

I called Mr. Jobman to inquire about the Section 7 requirements on the Souris Basin project. I gave a brief summary of the project and explained that the Bismarck field office had suggested we re-initiate section 7 consultation in their initial scoping letter (3 June 1986).

Mr. Johnson stated that it was not necessary to re-initiate coordination because of the work which had been done on the Lake Darling and Burlington projects. He agreed with the species I had identified (peregrine falcon, bald eagle, whooping crane, piping plover) and suggested that I include one or two paragraphs covering effects on there threatened and endangered species in the EIS. He also stated that it was not necessary to include a separate biological assessment of effects on threatened or endangered species in the EIS.

I agreed to the suggested approach and said that I would also include an explanation of the approach in the coordination section of the EIS.

John M. Kittelson, project biologist

DA FORM 1 APR 66 751 REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED

APPENDIX 9

BACKGROUND WATER QUALITY INFORMATION
SOURIS RIVER AS IT ENTERS THE U.S.

SOURCE:
Souris Basin Development Authority
Rafferty/Alameda Project
Environmental Impact Statement

NORTH DAKOTA WATER QUALITY STANDARDS
CLASS 1A WATERS

Substance or Characteristics	North Dakota Limitation
Ammonia (un-ionized) as N (diss)	.02 mg/1
Arsenic (Total)	.05 mg/1
Barium (diss)	1.0 mg/1
Boron (diss)	0.75 mg/1
Cadmium (Total)	.01 mg/1
Chlorides (diss)	100 mg/1
Chromuim (Total)	.05 mg/1
Copper (Total)(1)	.05 mg/1
Cyanides (Total)	.005 mg/1
Lead (diss)(1)	.05 mg/1
Phosphates (P)(diss)(2)	0.1 mg/1
Zinc (Total)(1)	1.0 mg/1
Selenium (Total)	.01 mg/1
Polychlorinated Biphenyls (Total)	.00015 mg/1
Dissolved Oxygen (not less than)	5.0 mg/1
pH	7.0-8.5
Temperature	85 degrees F. Maximum increase not more than 5 degrees F. above natural background conditions.
Fecal Coliform	Does not exceed geometric mean of 200 per 100 ml based on a minimum of no less than 5 samples obtained during separate 24-hour periods of any 30-day period, nor shall 10 percent of total samples exceed 400 per 100 ml. Only applies to recreational season 1 May to 30 September.
Sodium	50 percent of total cations as mg/1
	.01 mg/1
Phenols	.01 mg/1
Sulfates (diss)	250
Mercury (Total)	.002 mg/1

(1) More restrictive criteria may be necessary to protect fish and aquatic life.

(2) Standards for nitrates and phosphates are intended as guideline limits. The Department of Health reserves to review and to set specific limitations.

EXCERPTED FROM

PROPOSED RAFFERTY AND
ALAMEDA RESERVOIRS

WATER QUALITY
IMPACT ASSESSMENT

Prepared for

SOURIS BASIN
DEVELOPMENT AUTHORITY

By

R.A. McDonald, P.Eng.
M·R·2 - McDonald & Associates
Regina, Saskatchewan

in association with

H.R. Hamilton
HydroQual Consultants Inc.
Calgary, Alberta

May 1987

PROJECT NO. 7011

MR2

2.4 Souris River - Moose Mountain Creek to the International Border

.1 General Factors/Uses

From the mouth of Moose Mountain Creek, this 64.7 km reach to the U.S. border is characterized by a well defined river channel and banks. The only urban centre adjacent to the river is the Town of Oxbow. A shallow reservoir is created at Oxbow due to a small instream dam. The river traverses agricultural lands on which there is neighbouring petroleum activity.

Major uses include irrigation, recreation, and fish and wildlife. The Town of Oxbow uses a groundwater supply adjacent to the river for municipal purposes.

There are no point source discharges to this reach of the river. The Town of Oxbow's sewage lagoon, located to the southeast of the town and adjacent to the river, does not presently have a direct discharge. However, effluent loss through exfiltration towards the river is suspected. It is presumed that stock also have use of the river valleys. The chief impacts would include normal agricultural runoff, including that from range cattle, together with any groundwater inflows.

.2 Water Quality Observations

Within this reach of the river, the only Canadian station with any significant data base is a primary station south of Glen Ewen, which is utilized by both federal and provincial agencies. This station is approximately 29 km above the border. The United States Geological Survey maintains a station close to the border notated as at Sherwood. For this review, the federal-provincial data at Glen Ewen, together with the U.S. North Dakota information at Sherwood, were utilized. Following are some observations on major parameter groups. Emphasis is placed on the Glen Ewen data, but the Sherwood data are used for comparative purposes or where Canadian information is lacking.

a) Dissolved Salts

- Figure 2.25 indicates median and 25th and 75th percentile values for conductance for both Glen Ewen and Sherwood. The seasonal trends are quite similar and demonstrate increasing levels of conductance from the spring through to the winter. Typical values during the spring were in the range of 800 to 900 uS/cm with increases to around 1000 uS/cm in the summertime. During flow recession in the fall, conductance values climbed to the 1100 to 1200 uS/cm range

and under winter conditions, median values of approximately 1600 to 1800 uS/cm could be anticipated. Examination of seasonal paired data over the 1974 - 1984 years for both sites indicate significant variations each way during the spring period. During the summer and fall period, the data tended to be similar, although some years (under low flow conditions) conductances were higher at Glen Ewen. Winter data were rather similar.

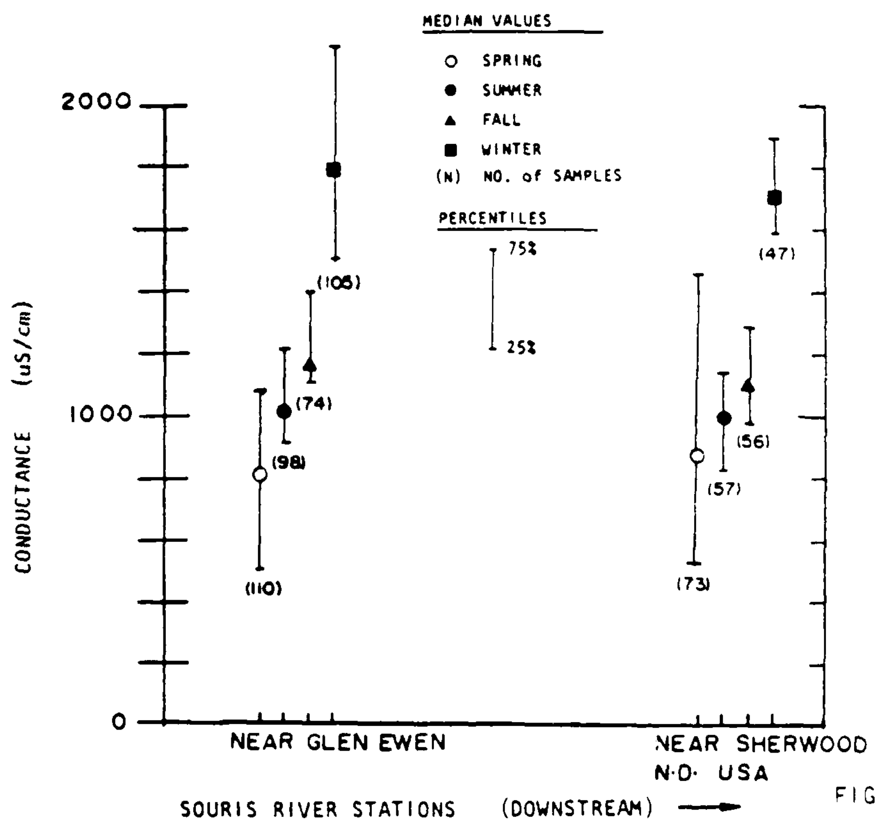


FIG. 2.25

- Data from an automatic, continuous monitor placed at the Glen Ewen site by Environment Canada from 1977 to 1982 yielded the following summary statistics for conductance in uS/cm.(Munro and Crosley 1984)

	n	Median	Range
Spring high flow period	91	643	260 - 1237
Low flow open water period	502	1260	644 - 1714
Low flow under ice cover period	156	1583	878 - 2142

- Based on Environment Canada and USGS data, the calculated relationships between conductance and total dissolved solids (TDS - expressed as sum of dissolved ions) were -

Glen Ewen: TDS = 0.766 x Cond. + 38 (n = 115; r = 0.949)
Sherwood: TDS = 0.887 x Cond. - 55 (n = 64, r = 0.983)

- Median chloride values for Glen Ewen (as shown on Figure 2.26) showed similar seasonal variations to that observed for conductance, but the ranges were relatively more substantial.

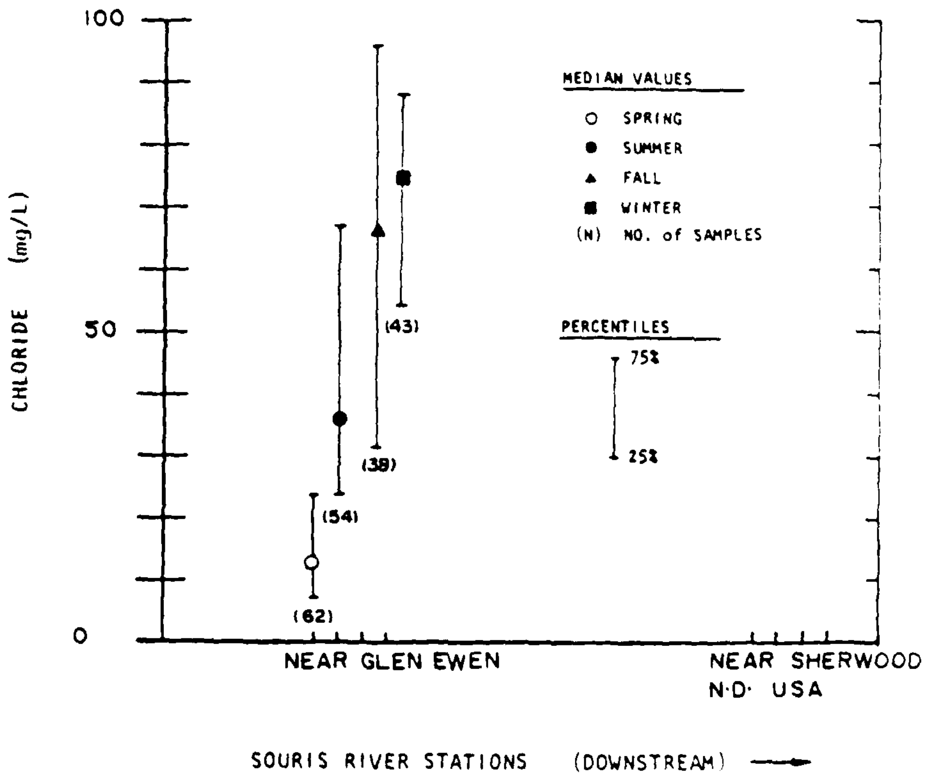


FIG. 2.26

Spring and summer median values were typically below 20 and 30, and 40 mg/L respectively, but during the fall and winter periods, median values ranged from approximately 65 to 75 mg/L. Comparison with the USGS data was similar to that observed for conductance. However, during the wintertime, chloride values tended to be high at Glen Ewen.

. Based on 1975-76 and 1982-84 major ion data at Glen Ewen, the primary cations varied among calcium, magnesium, and sodium. During the winter period, sodium tended to dominate, followed by magnesium and calcium. However, during the higher flow periods, calcium, followed by magnesium and sodium, sometimes predominated. However, on balance, the overall summer through winter periods indicated a high percentage of sodium--often greater than 50% of all of the cations. Of the anions, bicarbonate and sulphate comprised in excess of 90%. Bicarbonate tended to have a higher proportion during the spring runoff periods but in fall and winter, sulphate periodically had a higher percentage than that of bicarbonate. Sodium adsorption ratios calculated over the 1982 - 1984 spring and summer periods ranged from 1.1 to 4.4. At Sherwood, over comparable time periods, sodium similarly dominated the cation species. The SAR values for spring and summer ranged from 2 to 5.

b) Nutrients

. Seasonal median, and 25th and 75th percentile data for total phosphorus are plotted on Figure 2.27 for both the Glen Ewen and Sherwood sites. Both stations exhibit high spring and summer values with decreases during the fall and winter. Median ranges at Glen Ewen for spring and summer were 0.15 and 0.17 mg/L respectively, while for Sherwood, increases to 0.21 and 0.22 mg/L were noted. During the fall Glen Ewen median values dropped to 0.09 while Sherwood values were slightly higher at 0.13 mg/L. Winter values were in a similar range to that observed for the fall. Based on comparative seasonal data over the 1974 to 1983 years for both sites, it was noted that variabilities were encountered both ways during the spring. Summer, fall, and winter data tended to be relatively similar.

. Total kjeldahl nitrogen median and percentiles for both sites are plotted on Figure 2.28. The Sherwood data demonstrated much greater seasonal variability than that recorded for Glen Ewen. Typically, total kjeldahl nitrogen tended to decrease from the spring through fall seasons with increases measured during the winter period. Median values at Glen Ewen for the spring through fall seasons were relatively close and ranged from 1.25 mg/L in the spring to 1.1 mg/L during the

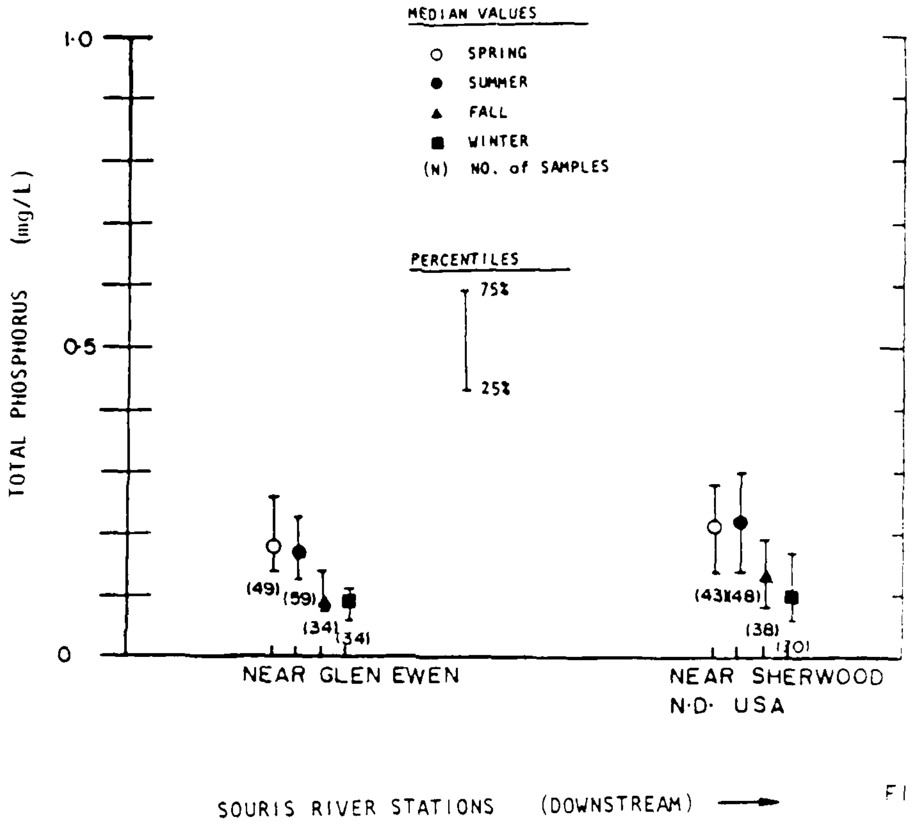
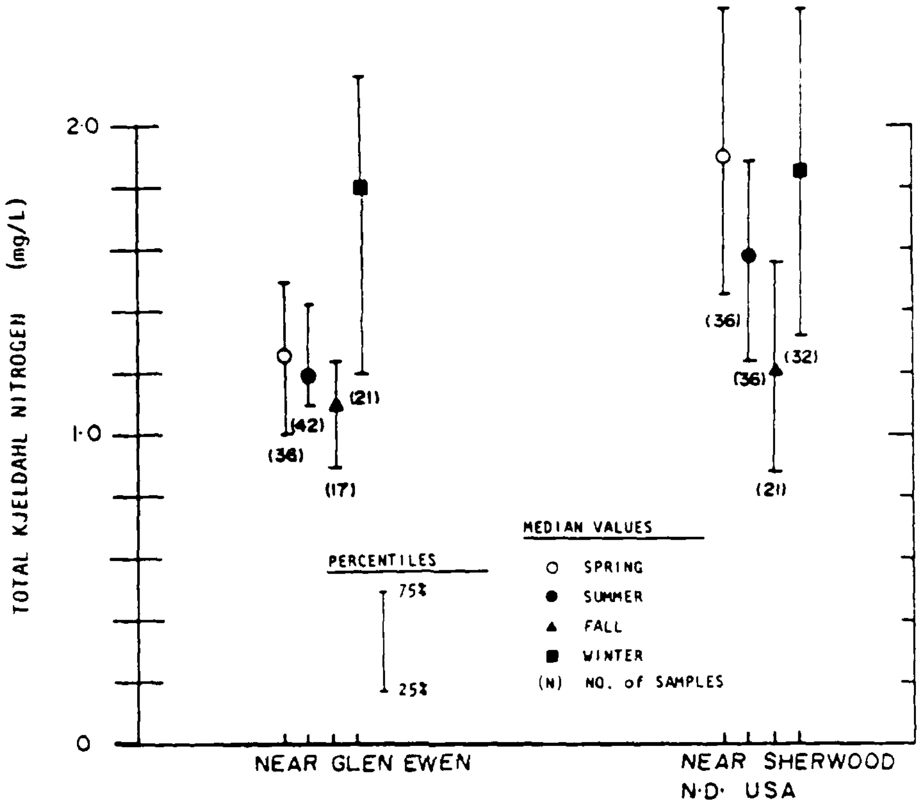


FIG. 2.27

fall. In the wintertime, median values of 1.8 were recorded. The data from Sherwood ranged from approximately 1.9 mg/L in the spring to 1.2 mg/L in the fall. Winter data were somewhat compatible. Based on a 1974-1977 review of similar seasonal data, the only significant differences observed between the two sites were during the fall and winter seasons. Both positive and negative variations occurred.



SOURIS RIVER STATIONS (DOWNSTREAM) → FIG. 2.28

. Ammonia nitrogen data for Glen Ewen was restricted to a small data base. Medians ranged from 0.1 mg/L in the summer to 0.80 mg/L in the winter. Using limited corresponding pH and temperature data, potential un-ionized ammonia concentrations were found to be very low with a maximum of only 0.002 mg/L. At Sherwood, with a greater data base, median ammonia values were found to range from 0.04 mg/L in summer to 0.47 mg/L during the winter. The maximum 90th percentile was 1.06 mg/L (winter). Estimated un-ionized ammonia nitrogen values were generally much less than 0.01 mg/L.

c) Dissolved Oxygen

. Median dissolved oxygen values for Glen Ewen are shown on Figure 2.29. Median values for the spring tended to be reasonably high at 8.8 mg/L but during the summer dropped to 7 mg/L. This is increased to 9.9 mg/L in the fall, but the winter median values were only 4.7 mg/L.

. Compared with Sherwood data over the period 1974 to 1981, seasonal assessments indicated reasonably similar concentrations during the summer and fall, variations in both directions during the spring; and in the wintertime, there was a tendency for lower reported values at the downstream site.

. Based on the available information at Glen Ewen, 23 winter, 2 summer, and 2 fall samples out of a total of 192 provincial and federal data points had dissolved oxygen levels less than 5 mg/L. From the USGS data, 41 winter, 2 spring, 3 summer, and 2 fall samples out of a total of 207 had levels below 5 mg/L.

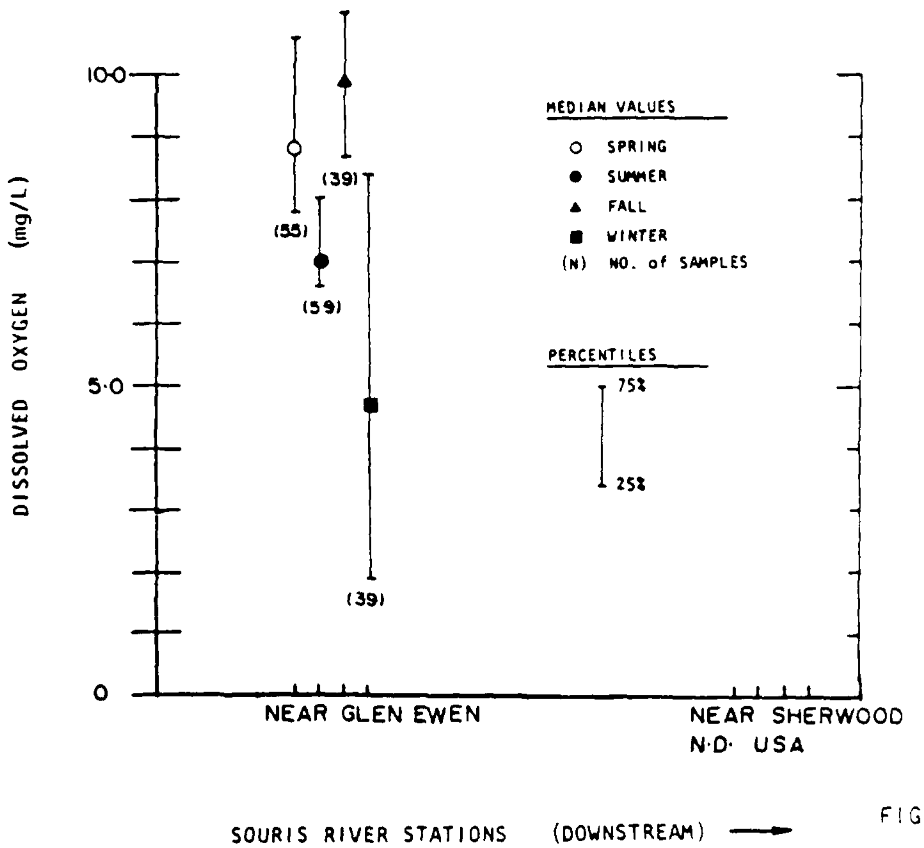


FIG. 2.29

. Although the reliability of the data over the entire 1977-82 monitoring period has been questioned, the Environment Canada automatic monitor at Glen Ewen suggested summer diurnal fluctuations of up to 8 mg/L.(Munro and Crosley 1984) Summary statistics produced the following dissolved oxygen concentrations (in mg/L) over the duration of operation:

	n	Median	Range
Spring high flow period	75	8.7	3.0 - 14.9
Low flow open water period	416	7.1	3.2 - 12.6
Low flow under ice period	135	7.2	1.0 - 14.9

d) Heavy Metals/Trace Substances

. Heavy metal and trace substance data are available for both the Glen Ewen, Saskatchewan, and Sherwood, North Dakota, stations. For many of the variables, a considerable amount of data are available. Summaries are presented for each station in Table 2.14 and 2.15.

. Much of the Canadian data are measured as the extractable form although a few of the parameters are expressed as dissolved. Generally for most of the heavy metals, the concentrations were relatively low. Periodic somewhat high detections had been observed for cadmium, copper, lead, mercury, and zinc. Extractable iron and manganese values have also been quite high. Of other substances, dissolved cyanide (measured as total cyanide), fluoride, and boron have yielded some significant concentrations. Boron values have been measured as high as 1.2 mg/L. During the spring, summer, and fall periods, 2 out of 61 samples had levels in excess of 0.5 mg/L.

TABLE 2.14

HEAVY METALS/TRACE SUBSTANCES

EXISTING QUALITY SUMMARY

Moose Mountain Creek to International Border (Glen Ewen)

Parameter	Form	Data Base: Period	Samples	Seasonal Distr.: Sp	Su	F	W	Range (mg/L unless noted)	Comments
Al	E	June 7/72 to Jan 5/78	39	12	10	6	11	L0.10 - 0.92	7 @ L0.10
As	D	June 7/72 to June 13/83	77	21	18	17	21	L0.005 - 0.036	8 @ L0.005
Ba	E	June 7/72 to July 10/84	68	21	17	11	19	L0.05 - 0.3	23 @ L0.1 4 @ L0.05 -winter values tend to be in upper range.
Be	E	July 29/75 to Jan 5/78	13	1	5	3	4	L0.01	13 @ L0.01
B	D	Mar 1/71 to Sept 20/83	83	21	22	18	22	0.14 - 1.2	-winter values tend to be in upper range.
Cd	E	Mar 1/71 to Mar 18/80	68	20	18	12	18	L0.001 - 0.014	57 @ L0.001 2 @ L0.002
Cr	E	June 7/72 to Jan 5/78	41	11	13	7	10	L0.010 - L0.015	20 @ L0.015 19 @ L0.010
Co	E	Mar 1/71 to Mar 18/80	71	21	19	11	20	L0.001 - 0.004	31 @ L0.002 15 @ L0.001
Cu	E	Mar 1/71 to Mar 18/80	71	22	18	11	20	L0.001 - 0.087	2 @ L0.001
CN^-	D	Feb 6/75 to Dec 19/84	84	21	22	18	23	L0.001 - 0.057	7 @ L0.005 3 @ L0.001
F	D	July 2/69 to Sept 20/83	215	66	57	39	53	L0.05 - 0.49	4 @ L0.05
Fe	E	June 7/72 to Mar 18/80	69	21	18	10	20	L0.04 - 3.00	1 @ L0.04 -fall values tend to be in lower range
	T	July 30/74	1	1	0	0	0	0.8	
Pb	E	Mar 1/71 to Mar 18/80	68	20	18	11	19	L0.001 - 0.14	41 @ L0.004 18 @ L0.001 -spring values tend to be in higher range.
Mn	D	Apr 4/72 to Dec 19/84	20	5	7	3	5	L0.01 - 0.96	3 @ L0.01 -winter values tend to be in higher range
	E	Mar 1/71 to Mar 18/80	68	20	18	10	20	L0.01 - 3.20	2 @ L0.01 -winter values tend to be in higher range
	T	July 30/74	1	1	0	0	0	0.02	
Hg	E	Mar 1/71 to Mar 5/79	64	19	19	10	16	L0.02 - 0.26 (ug/L)	35 @ L0.05 16 @ L0.02 -spring & summer values tend to be in higher range
	T	Apr 18/79 to Dec 19/84	58	17	15	12	14	L0.02 - 5.30 (ug/L)	36 @ L0.02 -one extreme spring value (5.00)
Mo	E	Jan 31/73 to Aug 5/73	29	9	8	4	8	L0.05 - L0.10	8 @ L0.10 21 @ L0.05
Ni	E	Mar 1/71 to Jan 5/78	41	13	10	6	12	L0.001 - 0.035	1 @ L0.002 5 @ L0.001
Se	D	Jan 3/73 to May 13/83	71	19	19	14	19	0.0003 - 0.0034	16 @ L0.0005 15 @ L0.001
Ag	E	June 7/72 to Feb 6/75	25	10	5	3	7	L0.004 - 0.07	2 @ L0.004 21 @ L0.01 -two values above detection limits in W. winter.
Sr	E	Mar 1/71 to Jan 5/78	38	11	9	6	12	0.15 - 1.46	-winter values tend to be in higher range
V	E	Jan 31/73 to Mar 18/80	55	18	13	8	16	L0.001 - L0.05	20 @ L0.05 4 @ L0.001
Zn	E	Mar 1/71 to Mar 18/80	71	21	18	11	21	L0.001 - 0.11	1 @ L0.01 15 @ L0.001

<u>Notes:</u> 1) L - less than
2) Sp - spring, Su - summer, F - fall, W - winter
3) Form - T - Total, D - Dissolved, E - Extractable

TABLE 2.15

HEAVY METALS/TRACE SUBSTANCES

EXISTING QUALITY SUMMARY

Moose Mountain Creek to International Border (Sherwood, North Dakota)

		Data Base							
				Seasonal Distr.				Range	
Parameter	Form	Period	Samples	Sp	Su	F	W	(mg/L unless noted)	Comments
Al	D	Nov 13/75 to July 16/86	32	12	5	10	5	0 - 0.05	2 @ L0.10 4 @ L0.01 2 @ 0
As	D	May 16/74 to July 16/86	27	11	3	10	3	L0.001 - 0.008	1 @ L1
Ba	D	Nov 13/75 to July 16/86	26	10	3	10	3	0.044 - 0.200	8 @ L0.100
Be	D	Nov 13/75 to Mar 31/81	12	6	0	6	0	0 - L0.010	7 @ L0.010 2 @ L0.001 3 @ 0
B	D	Apr 19/72 to Aug 28/86	126	39	32	25	30	0.040 - 1.100	
Cd	D	Nov 13/75 to July 16/86	30	12	3	10	5	0 - L0.003	2 not detected. 2 @ 0
Cr	D	Nov 13/75 to July 16/86	31	12	4	10	5	0 - 0.010	8 not detected. 2 @ 0 15 @ L0.010
Co	D	Nov 13/75 to July 16/86	31	12	4	10	5	0 - 0.003	4 not detected. 2 @ 0
Cu	D	May 16/74 to July 16/86	32	13	4	10	5	0 - 0.005	2 not detected 1 @ 0 1 @ L0.020
CN^-	D	Nov 13/75 to July 16/86	30	12	3	10	5	0.00 - L0.01	9 @ 0.00 21 @ L0.01
F	D	Nov 13/75 to Aug 28/86	90	27	27	21	15	0.0 - 0.40	
Fe	D	Apr 19/72 to July 16/86	59	22	11	15	11	L0.001 - 3.20	8 @ L0.010
Pb	D	May 16/74 to July 16/86	31	12	4	10	5	0 - 0.012	3 not detected 1 @ L0.200 2 @ 0
Li	D	Nov 13/75 to July 16/86	31	12	4	10	5	0.017 - 0.090	
Mn	D	Apr 19/72 to July 16/86	59	22	11	15	11	0.003 - 4.00	4 @ L0.010
Hg	D	Nov 13/75 to July 16/86	31	12	4	10	5	0 - 0.002 (ug/L)	5 @ L0.005
Mo	D	Nov 13/75 to July 16/86	31	12	4	10	5	L0.001 - 0.006	2 @ L0.010
Ni	D	Nov 13/75 to July 16/86	31	12	4	10	5	0 - 0.007	1 @ L0.002 1 @ L0.001
Se	D	May 16/74 to July 16/86	32	13	4	10	5	0 - 0.002	19 @ L0.001
Ag	D	Nov 13/75 to Mar 31/81	12	6	0	6	0	0.000	8 not detected 4 @ 0
Sr	D	Nov 13/75 to July 16/86	26	8	6	7	5	0.140 - 0.640	
V	D	Nov 13/75 to July 16/86	29	11	4	9	5	0 - 0.006	6 @ 0
Zn	D	May 16/74 to July 16/86	31	13	4	10	4	0.002 - 0.060	1 not detected. 4 @ L0.020 3 @ L0.003 1 @ L0.012

Notes: 1) L - less than
2) Sp - spring F - fall
Su - summer W - winter
3) Form - T - Total
D - Dissolved
E - Extractable

. The USGS data at Sherwood, listed in Table 2.15, contains most of the parameters as measured in the dissolved form due to the most extensive data base available. Subsequently the data between the two sites can not be specifically correlated. Except for some incidents where high manganese and iron have been observed, most of the dissolved heavy metals at Sherwood were detected only at relatively low concentrations. Dissolved boron over approximately 14 years of measurement has shown a considerable range with values up to 1.1 mg/L recorded. Over the spring, summer, and fall periods, 6 out of 96 samples have values in excess of 0.5 mg/L. Three, or 100% of the winter samples exceeded this number.

e) Biocides and Organochlorine Compounds

. A number of samples have been analyzed for biocides and organochlorine compounds at Glen Ewen and at the American Sherwood station. Due to uncertainties in terms of methodologies and variations in the scope of constituents determined, summaries for each site are prepared separately in Tables 2.16 and 2.17. At the Glen Ewen site, based on federal data, the only detections were 2,4-D, 2,4,5-T, lindane, and alpha-BHC. 2,4-D was detected at levels greater than 0.004 ug/L in 61% of the samples with a maximum up to 0.79 ug/L. 2,4,5-T was only in excess of detection limits on 6% of the samples. The pesticides lindane and alpha-BHC were also commonly measured albeit at low levels. The isomer, alpha-BHC, detected in excess of 0.01 ug/L to 0.02 ug/L approximately 96% of the time. Lindane was somewhat less prevalent and trace amounts (up to 0.004 ug/L) were measured 48% of the time.

. At the Sherwood site, USGS data indicates very low incidence of detections for chlorinated pesticides including chlordane, DDT, and dieldrin, heptachlor, and heptachlor epoxide (one sample each only). 2,4-D and 2,4,5-T were also detected with 2,4-D being the most prevalent. All other constituents were reported as not detected over the years 1975 to 1981.

TABLE 2.16

BIOCIDES AND ORGANOCHLORINE COMPOUNDS

EXISTING QUALITY SUMMARY

Moose Mountain Creek to International Border (Glen Ewen)

	Data Base							
			Seasonal Distr.					
Parameter	Period	Samples	Sp	Su	F	W	Range (ug/L unless noted)	Comments
2,4-D	Jun 07/72 to Dec 19/84	110	33	29	20	28	L0.004 - 0.79	43 @ L0.004 -highest values in spring and summer
2,4,-DB	Sep 13/72 to Dec 19/84	111	32	29	21	29	L0.006 - L0.009	109 @ L0.009 2 @ L0.006
2,4-DP	Sept 13/72 to Dec 19/84	110	32	29	20	29	L0.002 - 0.015	107 @ L0.004 1 @ L0.002 -2 values above detection limit in winter
2,4,5-T	Jun 07/72 to Dec 19/84	111	33	29	20	29	L0.001 - 0.05	102 @ L0.002 1 @ L0.001 1 @ L0.018
MCPA	Dec 09/72 to Dec 19/84	109	32	28	20	29	L0.2	108 @ L0.2 1 @ L0.3
Silvex	Jun 05/78 to Dec 19/84	63	18	14	13	18	L0.004	63 @ L0.004
Picloram	Oct 03/78 to Dec 19/84	57	15	13	11	18	L0.2	57 @ L0.2
Aldrin	Oct 20/75 to Dec 19/84	74	19	19	15	21	L0.001	74 @ L0.001
Alpha-BHC	Sep 04/75 to Dec 19/84	83	20	22	18	23	L0.001 - 0.020	3 @ L0.001
Gamma-BHC (Lindane)	Mar 01/71 to Dec 19/84	116	32	33	20	31	L0.001 - 0.005	59 @ L0.001 1 @ L0.005
Gamma-Chlordane	Apr 04/78 to Dec 19/84	70	19	18	14	19	L0.002	70 @ L0.002
Dieldrin	Oct 20/75 to Dec 19/84	74	19	19	15	21	L0.002	74 @ L0.002
Endrin	Apr 04/78 to Dec 19/84	70	19	18	14	19	L0.002 - L0.003	69 @ L0.002 1 @ L0.003
Hexachlorobenzene	Jun 05/78 to Dec 19/84	68	17	18	14	19	L0.001	68 @ [illegible]
O,P-DDT	Jun 05/78 to Dec 19/84	68	17	18	14	19	L0.001 - L0.004	57 @ [illegible] 1 @ L0.004
P,P-DDT	Mar 01/71 to Dec 19/84	105	31	28	17	29	L0.004 - L0.005	104 @ L0.004 1 @ L0.005
Mirex	Jun 05/78 to Dec 19/84	68	17	18	14	19	L0.001	68 @ L0.001
Aroclor 1248 (PCB's)	Dec 09/72 to Feb 26/81	81	21	24	13	23	L0.002 - L0.024	40 @ L0.002 7 @ L0.02 34 @ L0.024
Aroclor 1254 (PCB's)	Dec 09/72 to Aug 22/83	101	28	31	15	27	L0.002 - L0.032	60 @ L0.002 7 @ L0.03 34 @ L0.032
Aroclor 1260	Jun 28/73 to Aug 22/83	88	20	31	15	22	L0.005 - L0.1	60 @ L0.005 20 @ L0.055 7 @ L0.06 1 @ L0.1
Aroclors, Total	Jan 21/80 to Dec 19/84	47	13	13	9	12	L0.002 - L0.02	37 @ L0.002 10 @ L0.02

Notes: 1) L - less than
2) Sp - spring F - fall
Su - summer W - winter

TABLE 2.17

BIOCIDES AND ORGANOCHLORINE COMPOUNDS

EXISTING QUALITY SUMMARY

Moose Mountain Creek to International Border (Sherwood, North Dakota)

Parameter	Data Base: Period	Samples	Seasonal Distr.: Sp	Su	F	W	Range (ug/L unless noted)	Comments
2,4-D	Nov 13/75 to Mar 31/81	23	6	5	5	7	0 - 0.24	
2,4,5-T	Nov 13/75 to Mar 31/81	23	6	5	5	7	0 - 0.01	1 @ 0.01
Silvex	Nov 13/75 to Mar 31/81	23	6	5	5	7	0	
Aldrin	Nov 13/75 to July 7/81	24	6	6	5	7	0	
Chlordane	Nov 13/75 to July 07/81	24	6	6	5	7	0 - 0.1	1 @ 0.1
Dieldrin	Nov 13/75 to Jul 07/81	24	6	6	5	7	0.0.03	1 @ 0.03
Endosulfan	Jan 18/77 to Jul 07/81	19	5	5	3	6	0	
Endrin	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
Heptachlor	Nov 13/75 to Jul 07/81	24	6	6	5	7	0 - 0.15	1 @ 0.15
Heptachlor Epoxide	Nov 13/75 to Jul 07/81	24	6	6	5	7	0 - 0.02	[illegible]
DDT	Nov 13/75 to Jul 07/81	24	6	6	5	7	0 - 0.02	1 @ 0.02
DDD	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
DDE	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
Methoxychlor	Oct 01/80 to Jul 07/81	4	1	1	1	1	0	
Mirex	Jul 19/78 to Jul 07/81	13	3	4	2	4	0	
Toxaphene	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
Diazinon	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
Ethion	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
Malathion	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
Parathion	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
Methyl-Parathion	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
Trithion	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
Methyl-Trithion	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	
PCB	Nov 13/75 to Jul 07/81	24	6	6	5	7	0	

Notes: 1) L - less than
2) Sp - spring F - fall
Su - summer W - winter

f) Bacteriology

. Data for total coliforms at Glen Ewen are limited. Median values during the summertime have been recorded at 500 organisms per 100 mL or less. During the fall, the median values were 230 with the high 75th percentile of 2100 per 100 mL.

. Fecal coliform data are similarly sparse. During the fall, median values of 330 coliforms per 100 mL were recorded based on only 6 samples. Limited data on fecal streptococci were also available. The summer median was recorded as 70 organisms per 100 mL.

g) Miscellaneous

. Colour and turbidity data for both Glen Ewen and Sherwood were examined over the periods 1976 to 1981 and 1974 to 1984 respectively. Colour tended to be variable, although values at Glen Ewen were observed to be higher in some years. On the other hand, turbidity data indicated higher values at Sherwood during the summer through winter periods. During the spring, both positive and negative variations were recorded.

. Total organic carbon was also compared on a seasonal basis for the two stations. Generally they were comparable within the period 1974-78 but there were some tendencies for higher concentrations at Glen Ewen.

h) Aquatic Biology

. Data available for this reach is limited to that gathered under the Souris River Basin Study (1978) at the Glen Ewen sampling station.

. Phytoplankton were found to contain primarily green algae (Chlorophyta) and diatoms (Bacillariophyceae) during the spring, summer, and fall, with low but consistent populations of pigmented flagellates (Euglenophyta). Both the green algae and diatoms had wide variety, and diversity indices were high averaging 1.1, although the number of organisms tended to be low. Blue-green algae (Cyanophyta) were found to be only sporadically present.

. Limited chlorophyll a data were available for the Glen Ewen site. Median summer values were 50 mg/m³, with ranges up to 26 mg/m³ (90th percentile). Spring, fall, and winter values tended to be less.

- Zooplankton populations at Glen Ewen were found to consist exclusively of members of the Cladocera and the Copepoda. There were extreme fluctuations in types and numbers of organisms throughout the year and from year to year with a certain species or groups increasing or decreasing to the point of absence from one period to another. However, it was found on balance that a low diversity index of less than 0.1 occurred.(Souris River Basin Study 1978) It is unclear whether this was due to the lack of protective aquatic vegetative habitat or to poor water quality.

- Benthic invertebrates were found to be characterized by dramatic seasonal and annual fluctuations in population types and numbers due to climatological influences.(Souris River Basin Study 1978) Predominant bottom dwellers consisted of Amphipoda, Diptera, Ephemeroptera, Gastropoda, Oligochaeta, and Pelecypoda. The numbers of organisms were quite low and the resulting diversity index of L0.1 may be due to an unsuitable habitat. Significant populations of dipteran larvae, Ephemeroptera, and Pelecypoda had been observed in the fall.(Souris River Basin Study 1978)

- As reported under the Souris River Basin Study (1978), no aquatic vascular vegetation was reported, possibly due to the lack of suitable habitat for rooting of emergent or submergent plants.

.3 Comments

Due to the monitoring activities of Saskatchewan Environment, Environment Canada, and the U.S. agency, a reasonably good water quality data base exists for this reach of the river. In similar fashion to many of the upstream reaches, the water quality in this lower portion is subject to seasonal and flow regime impacts. In particular, the level of conductance or total dissolved salts varies considerably with the seasons. Levels are generally good during spring and summer and deteriorate through the fall and winter. The increases during the fall and winter would be largely attributable to low flows, potential groundwater inputs, and ice cover concentration effects. In addition, some changes over the seasons have been noted with the predominant salt constituents. During the high TDS situations, sodium sulphate normally

predominates compared with calcium bicarbonate during high flow and low TDS periods. Periodically high sodium adsorption ratios (G3) have been encountered in the summer period.

Of the nutrients, total kjeldahl nitrogen is also typically higher in the wintertime over that measured during the open water period. In contrast, spring and summer phosphorus values tend to be higher than those observed during the fall and winter. Nevertheless, for both of the nutrients, concentrations appear to be sufficient to provide nutrient sources for aquatic vegetation. Based on limited ammonia data, the un-ionized ammonia concentrations would appear to be quite low.

Dissolved oxygen has been observed to be subject to considerable open water diurnal variations--probably due to oxygen production/ respiration cycles associated with photosynthetic processes. Some incidents of low levels, i.e. below 5 mg/L have been encountered. These are particularly noted under ice cover or non-reaeration conditions.

Information on aquatic biological growths within this reach are essentially limited to the information gathered during the Souris River Basin Study. At that time, typical algal populations and species were found but in types and numbers not normally considered to be a nuisance. Zooplankton and benthic invertebrate populations have shown significant fluctuations. The reported absence of emergent and/or submergent vegetation is postulated to be due to the habitat constraints within the reach.

Water colour has been recorded at high values with the spring and summer seasons generally considerably greater than observed during the fall/winter. Median turbidity levels, based on Glen Ewen measurements, tended to be quite low for all seasons.

With respect to heavy metals and trace substances, available data suggests that these are generally at low levels although some positive detections have been noted. Dissolved boron has been present in the water, but during the irrigation season, generally at levels less than 0.5 mg/L. Typical low level detections of biocides such as 2,4-D, lindane, and alpha-BHC have been noted.

Bacteriological data are inadequate to properly describe the quality from this aspect.

APPENDIX 10

Hydrographs Comparing Existing and
with Project Flows for Historic
and Synthetic Flood Events

KEY TO HYDROGRAPHS

YEAR	FREQUENCY	PLATES
1969	17-yr	D-1 to D-7
1974	15-yr	D-8 to D-14
1975	19-yr	D-15 to D-21
1976	45-yr	D-22 to D-28
1979	22-yr	D-29 to D-35
1982	8-yr	D-36 to D-42
1979 x 1.5	50-yr	D-43 to D-49
1976 x 1.3	70-yr	D-50 to D-56
1979 x 2.0	100-yr	D-57 to D-63
1976 x 1.5	100-yr	D-64 to D-70

SOURIS RIVER AT SHERWOOD

FLOOD OF 1969

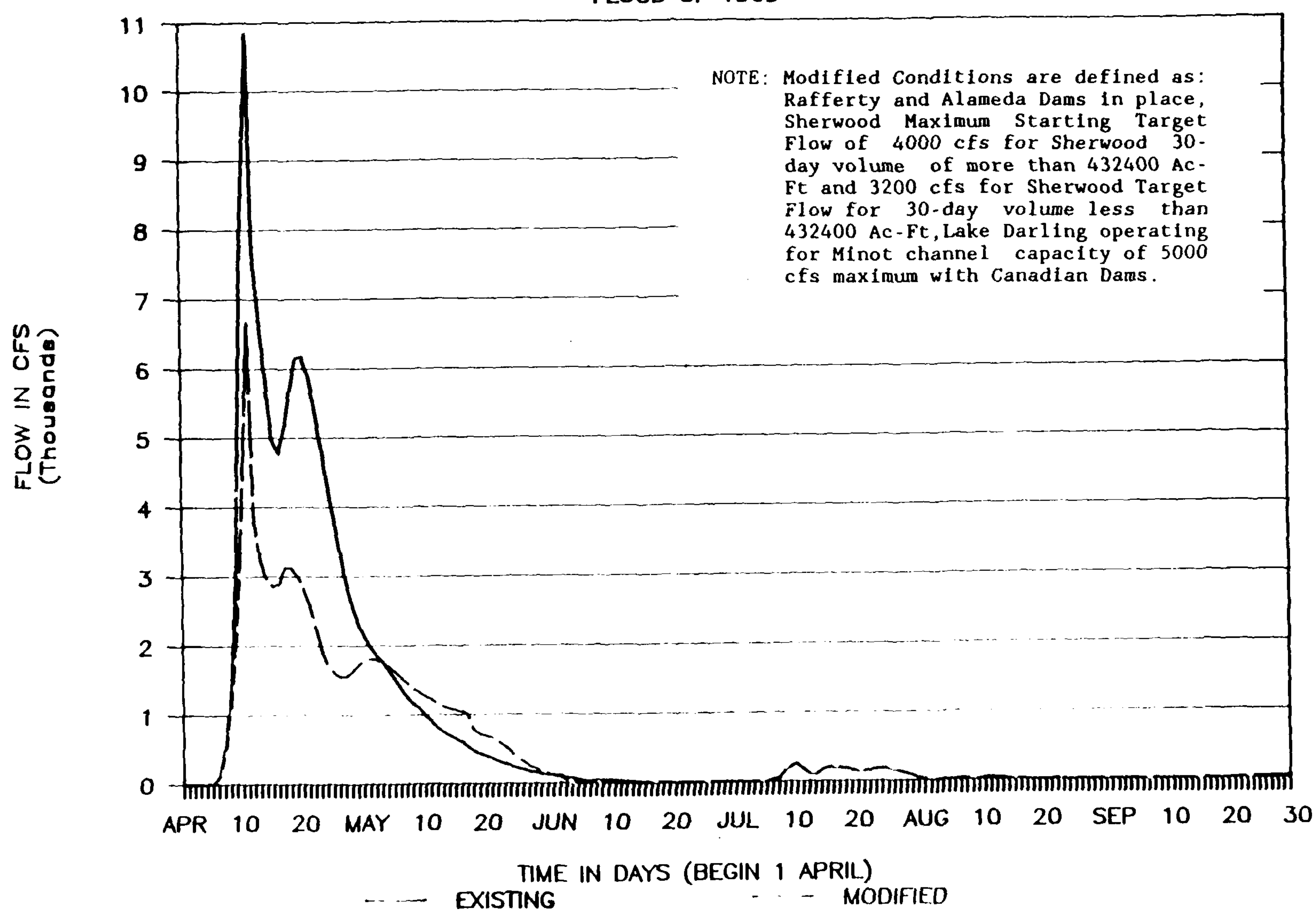


PLATE D-1

ELEVATIONS AT LAKE DARLING

FLOOD OF 1969

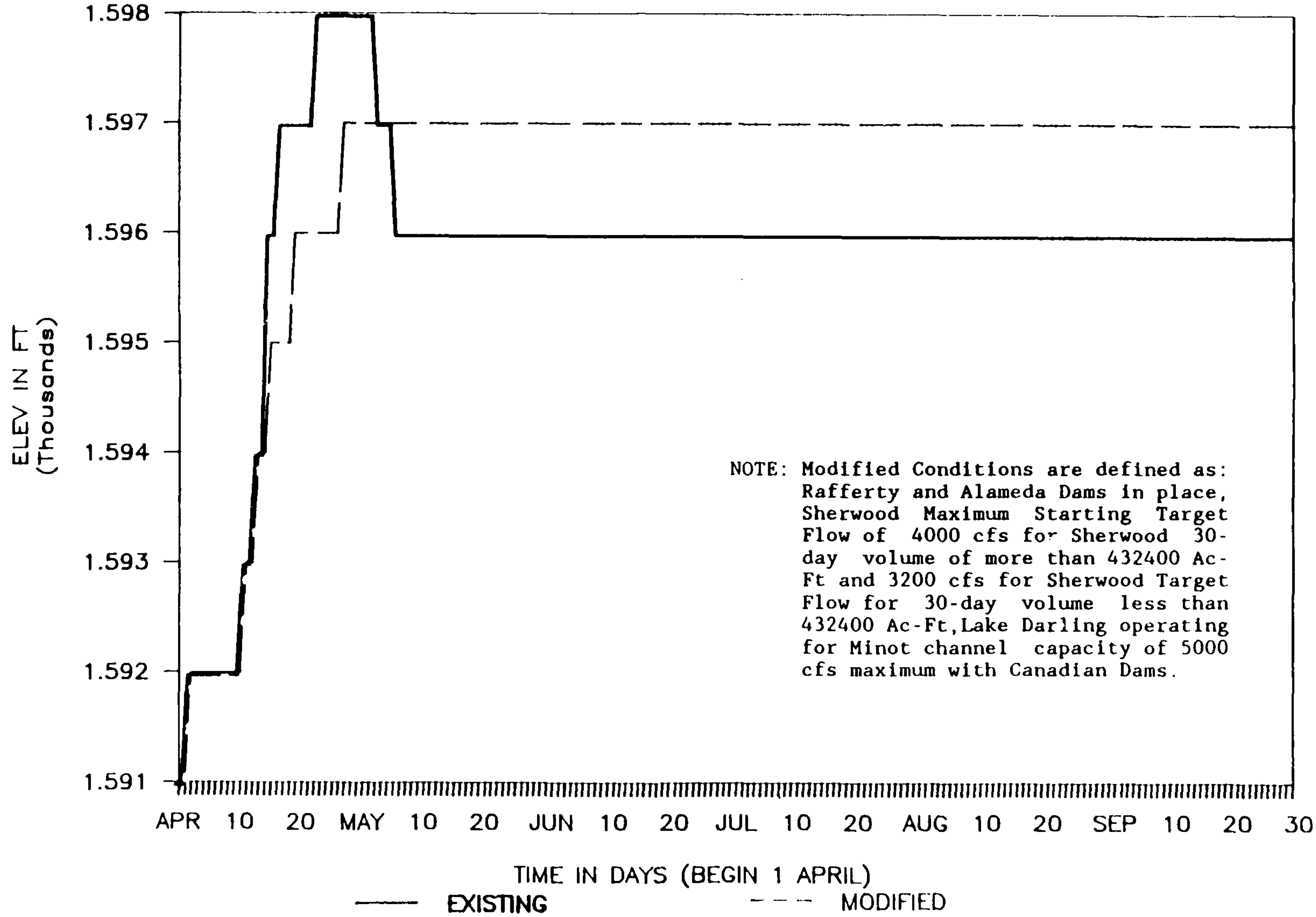
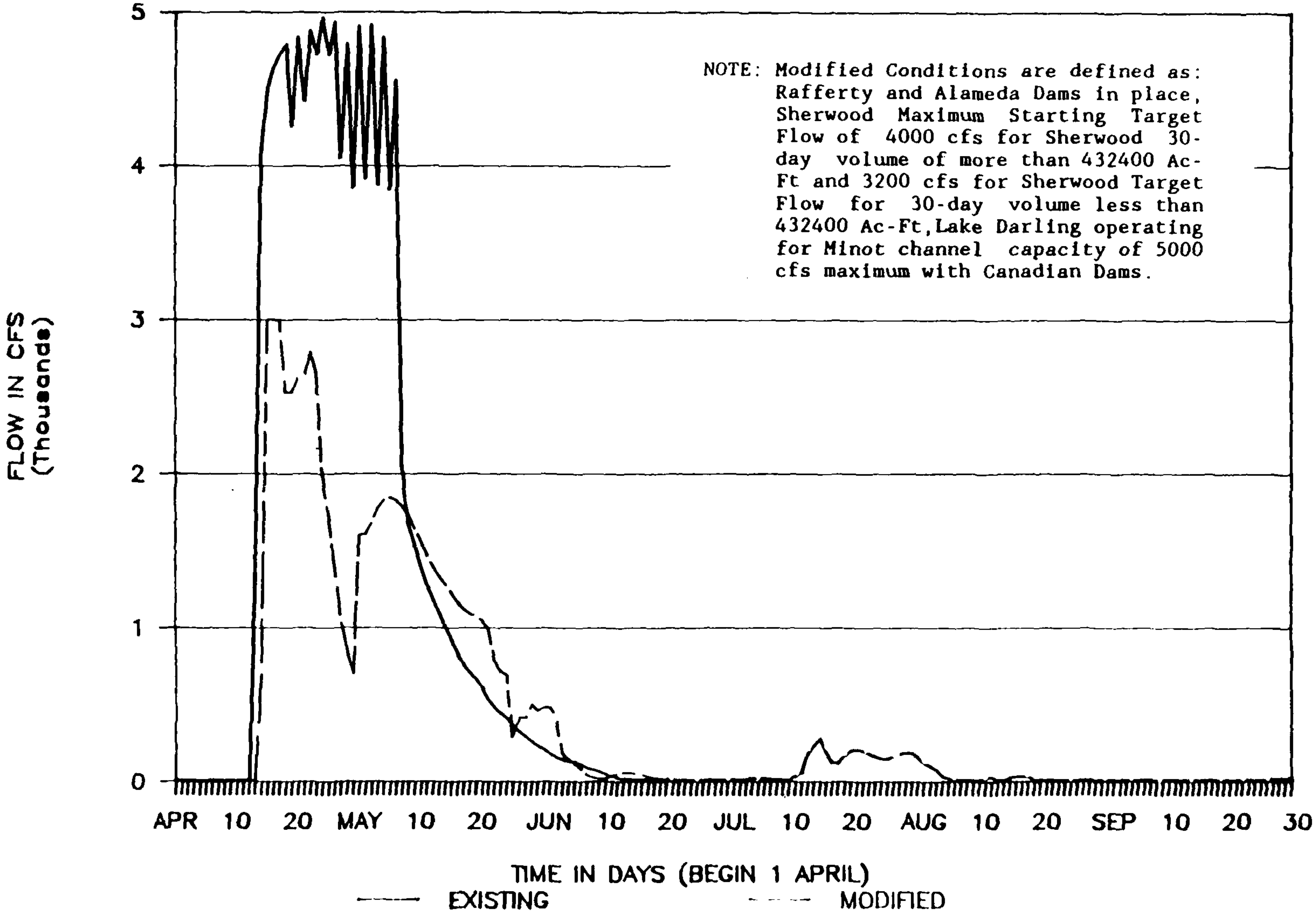


PLATE D-2

SOURIS RIVER AT FOXHOLM

FLOOD OF 1969



NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.

PLATE D-3

SOURIS RIVER AT MINOT

FLOOD OF 1969

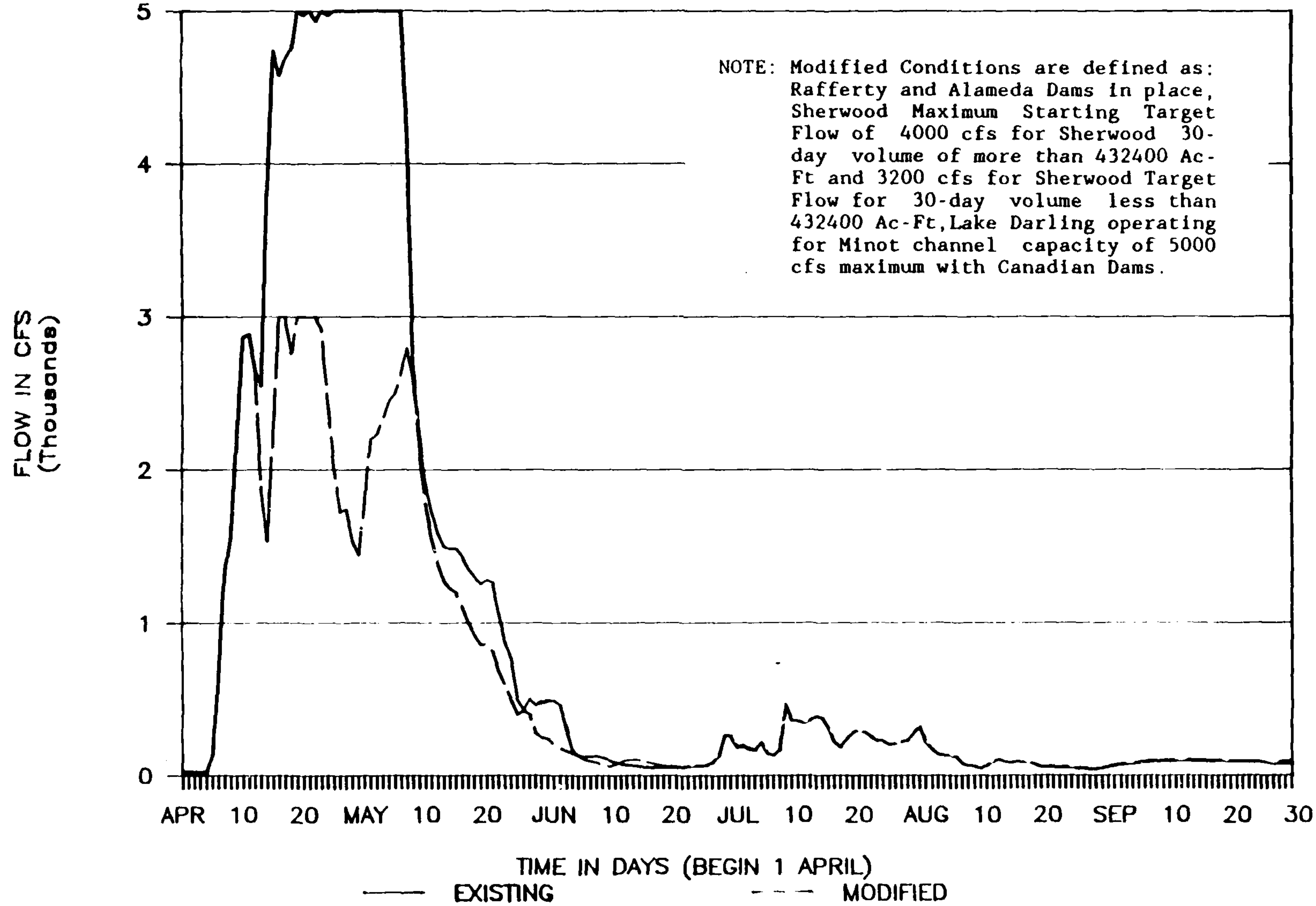
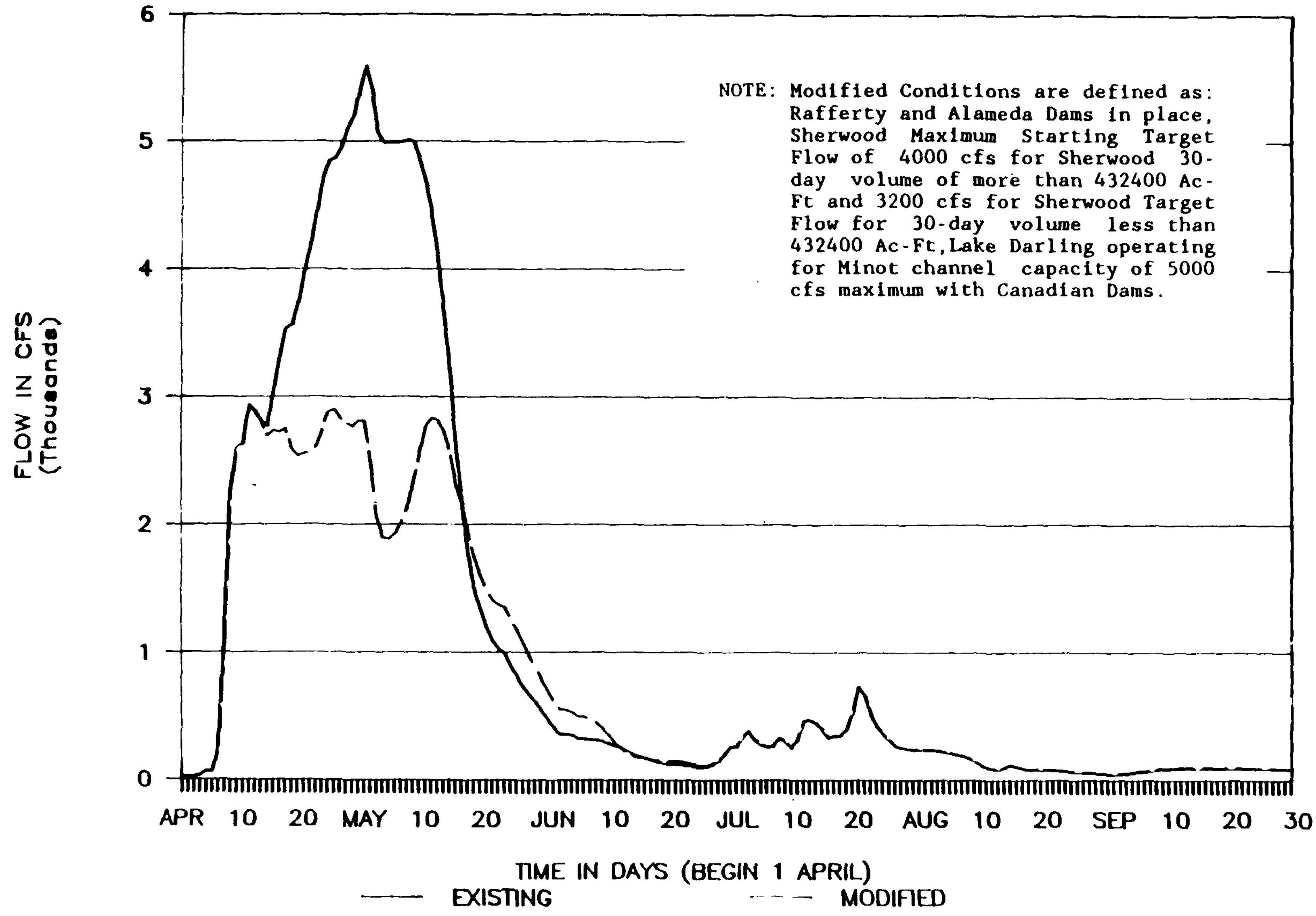


PLATE D-4

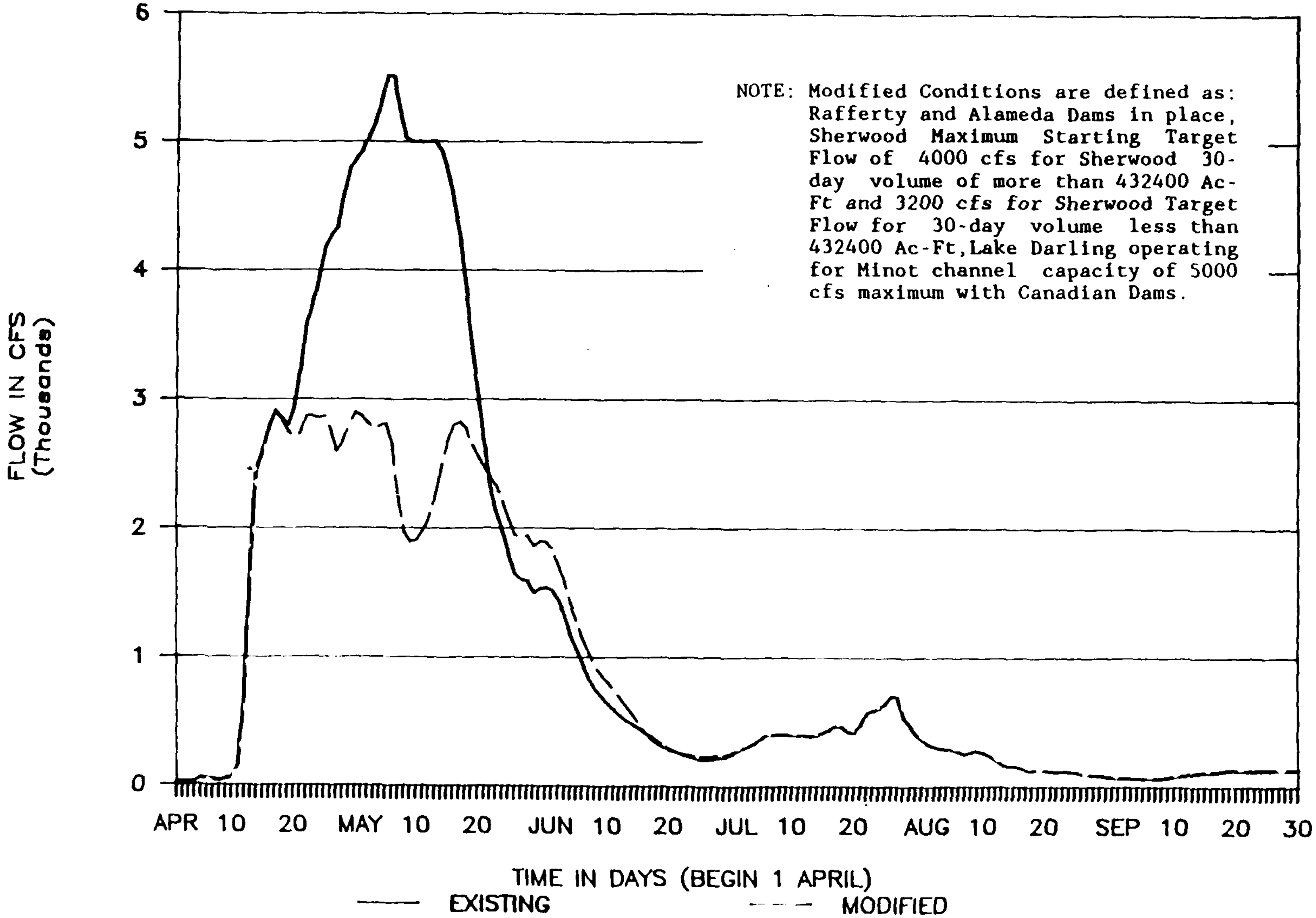
SOURIS RIVER AT VERENDRYE

FLOOD OF 1969



SOURIS RIVER AT BANTRY

FLOOD OF 1969



SOURIS RIVER AT WESTHOPE

FLOOD OF 1969

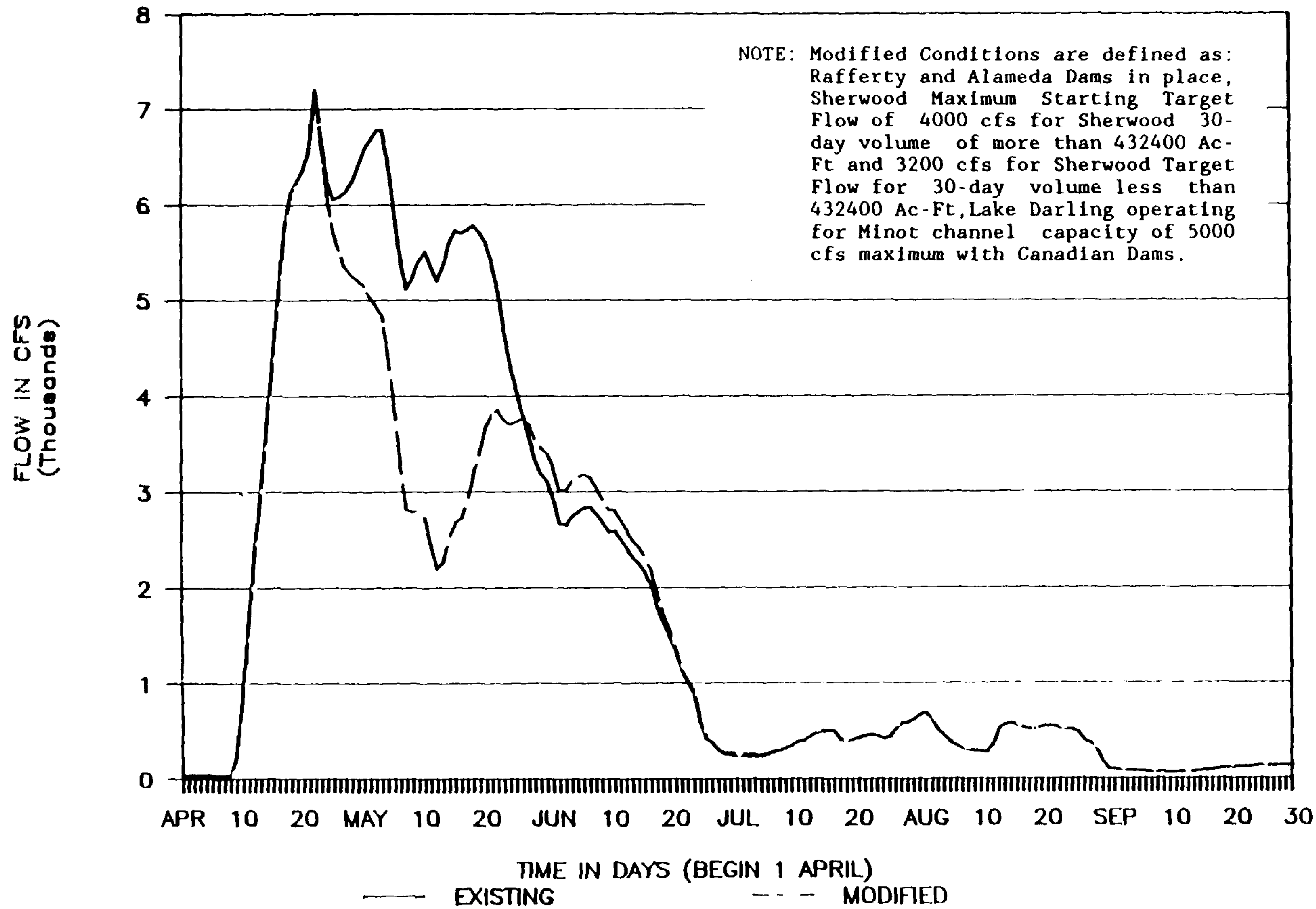


PLATE D-7

SOURIS RIVER AT SHERWOOD

FLOOD OF 1974

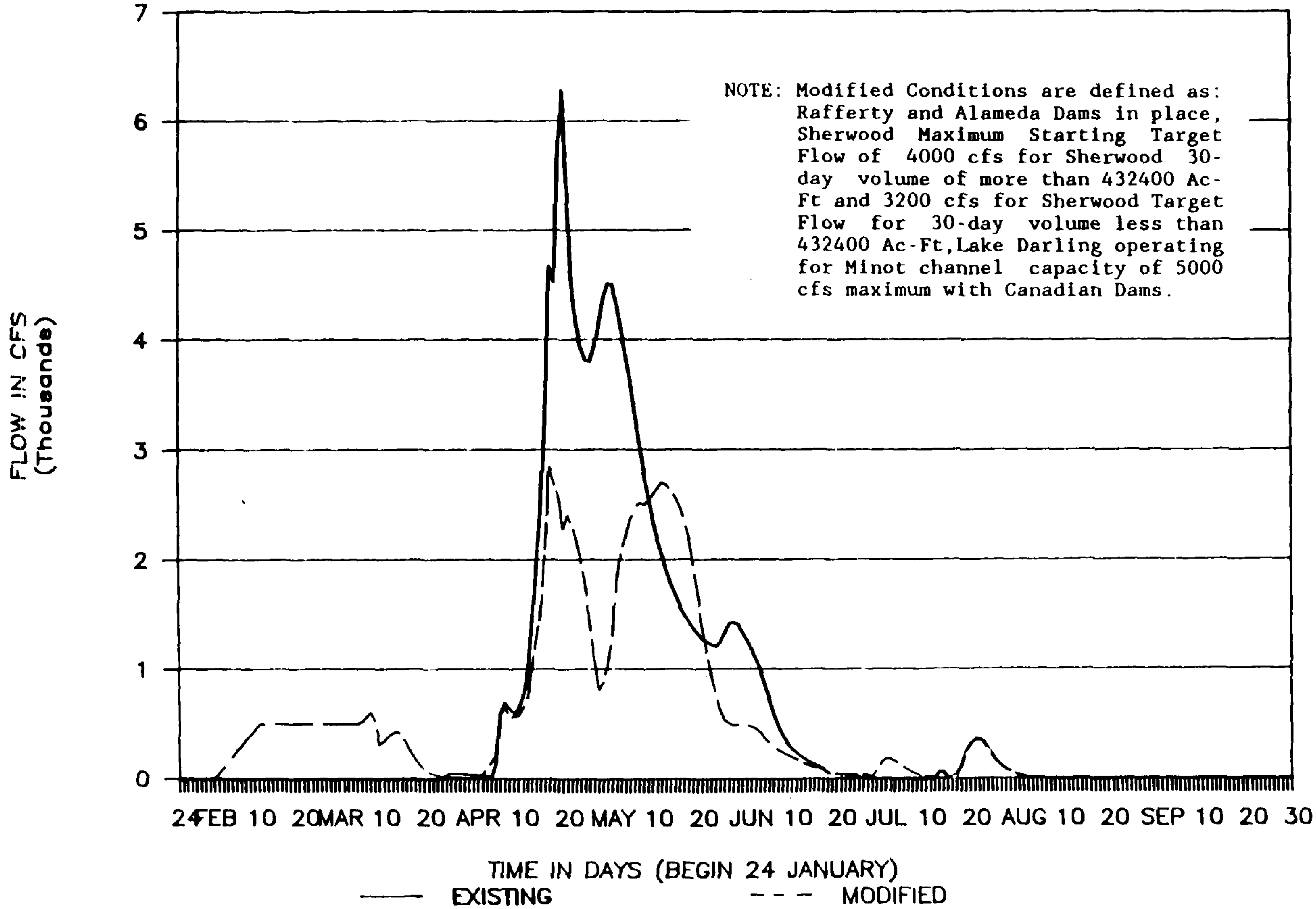
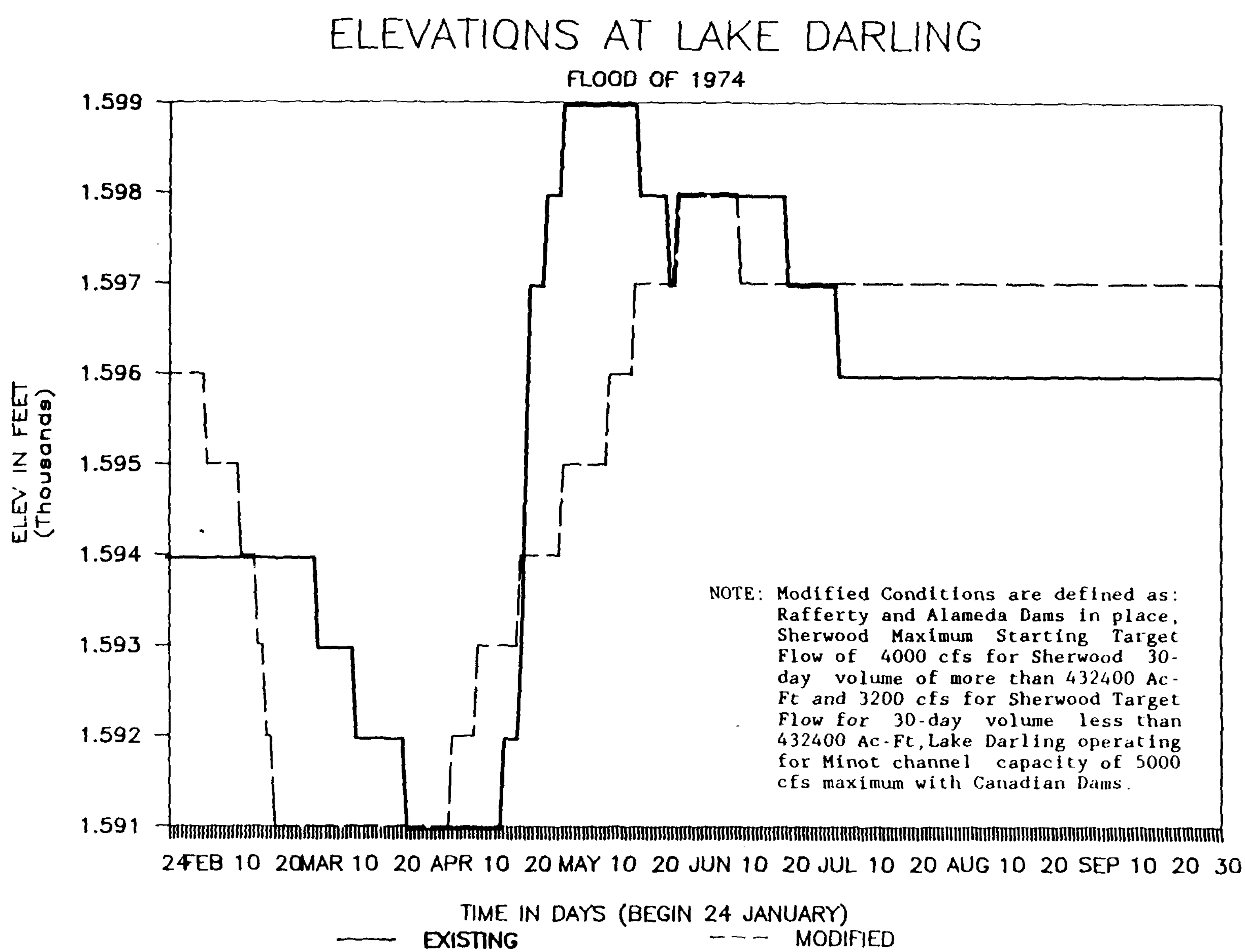


PLATE D-8

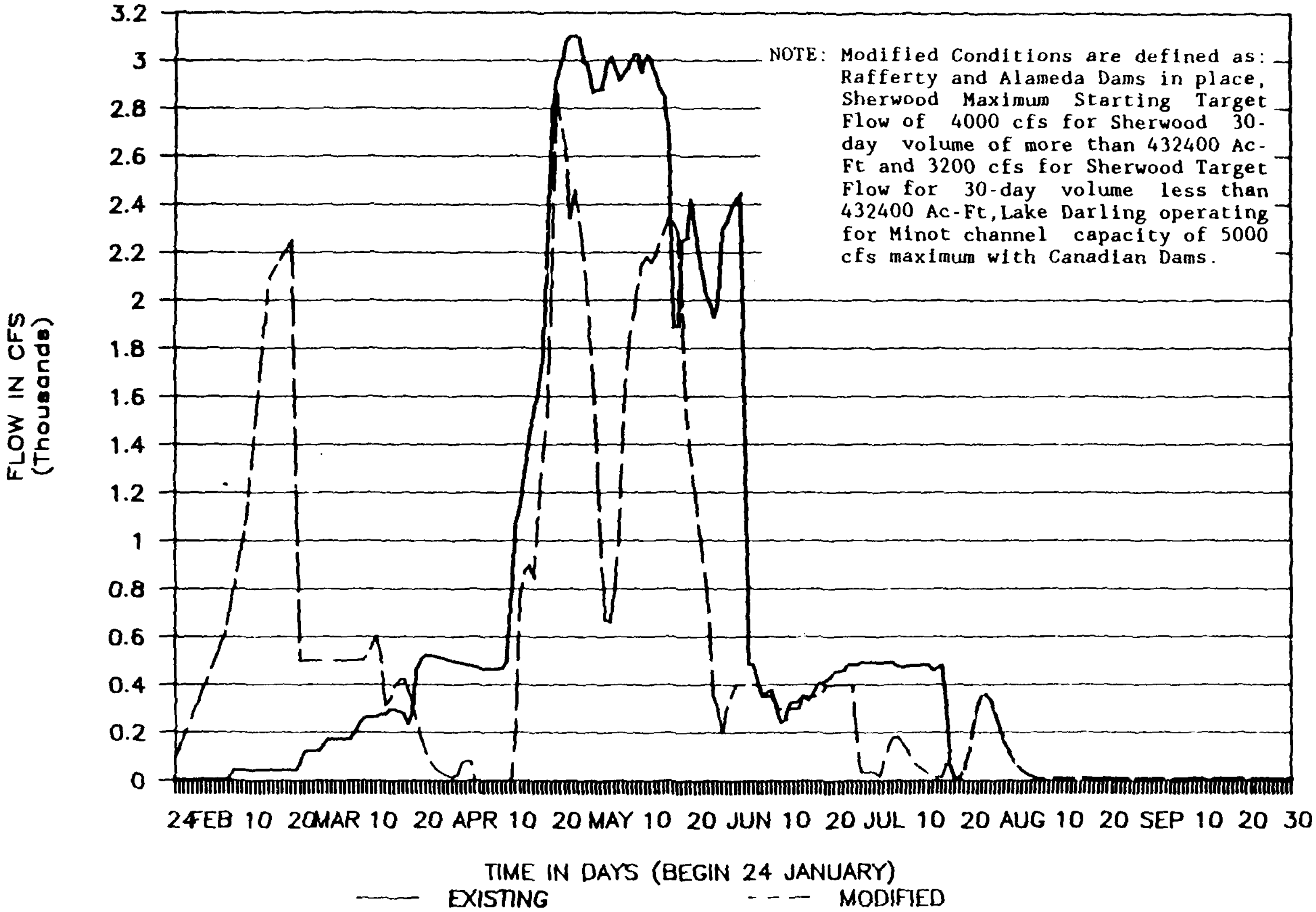


ELEVATIONS AT LAKE DARLING
FLOOD OF 1974
ELEV IN FEET (Thousands)
1.599
1.598
1.597
1.596
1.595
1.594
1.593
1.592
1.591
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
24FEB 10 20MAR 10 20 APR 10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30
TIME IN DAYS (BEGIN 24 JANUARY)
EXISTING
MODIFIED

PLATE D-9

SOURIS RIVER AT FOXHOLM

FLOOD OF 1974



SOURIS RIVER AT MINOT

FLOOD OF 1974

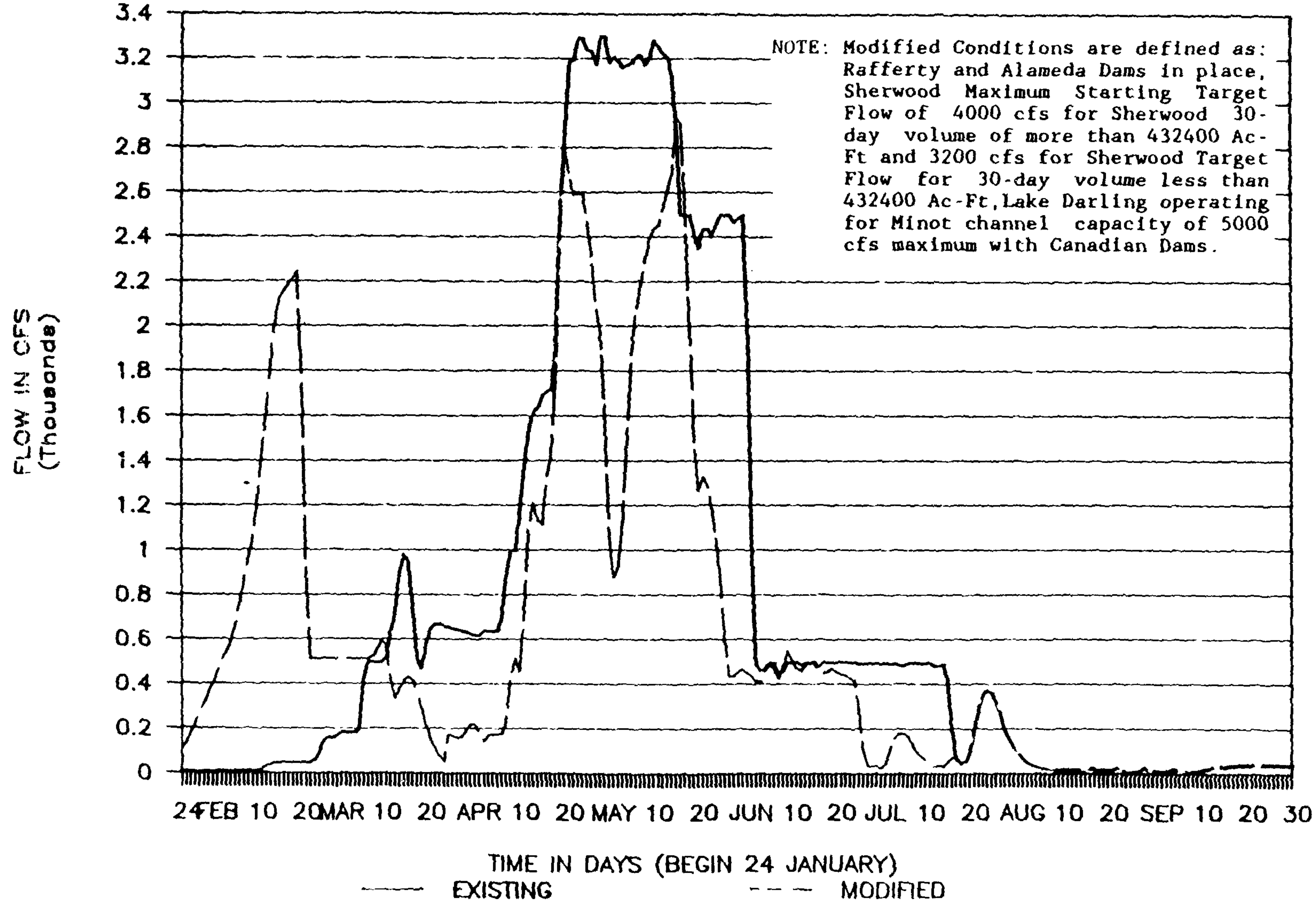


PLATE D-11

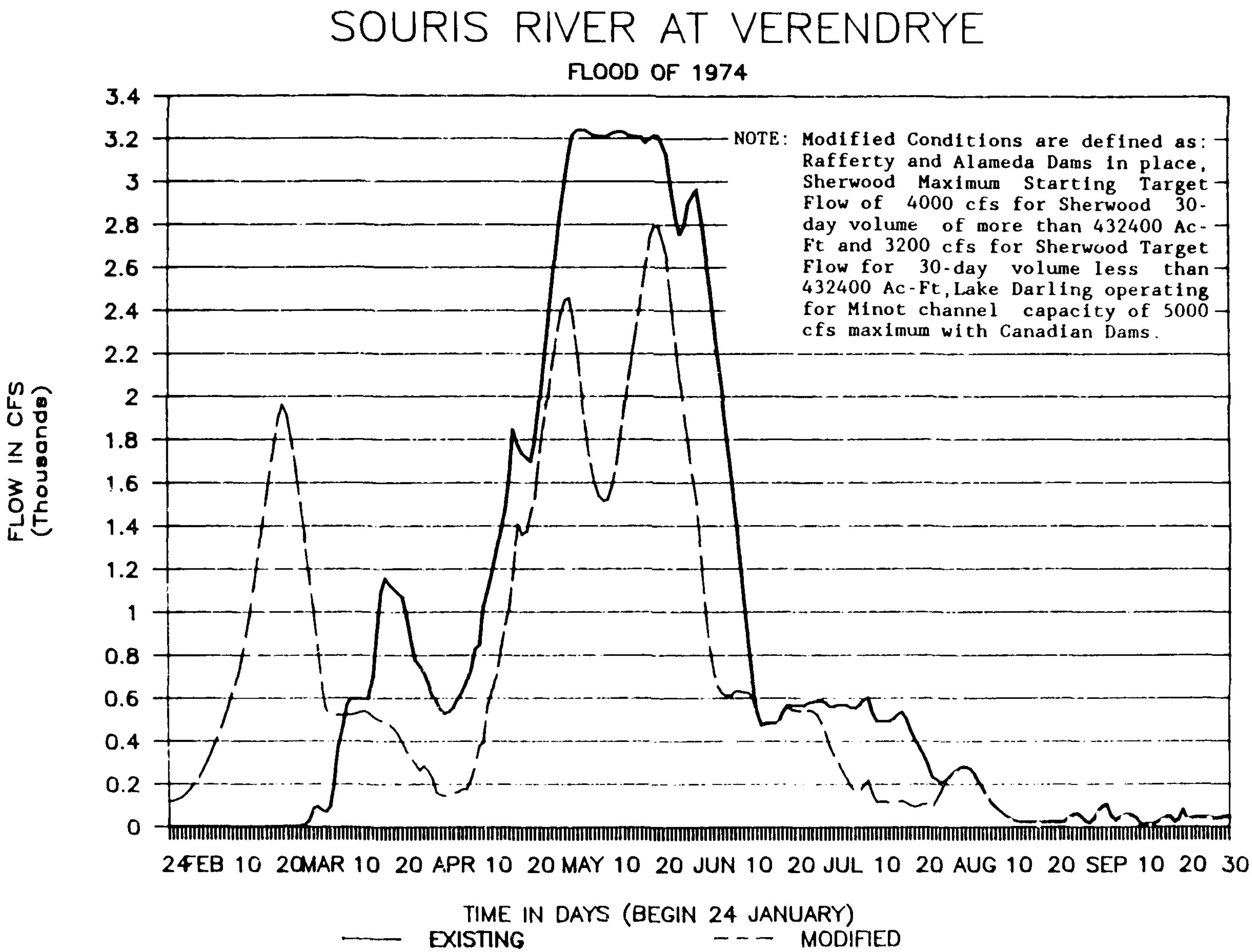

SOURIS RIVER AT VERENDRYE
FLOOD OF 1974
FLOW IN CFS (Thousands)
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
24FEB 10 20MAR 10 20 APR 10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30
TIME IN DAYS (BEGIN 24 JANUARY)
EXISTING
MODIFIED

PLATE D-12

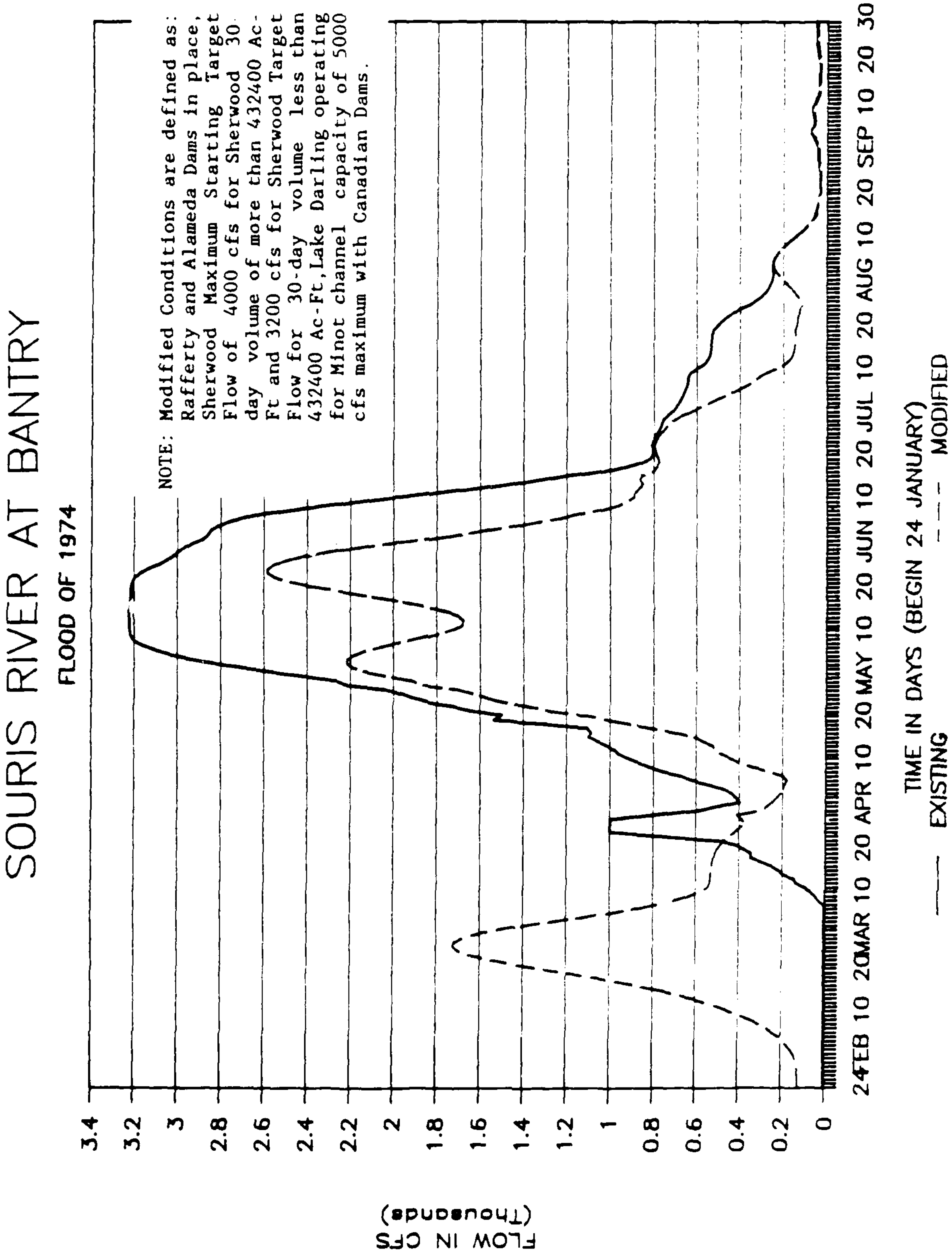
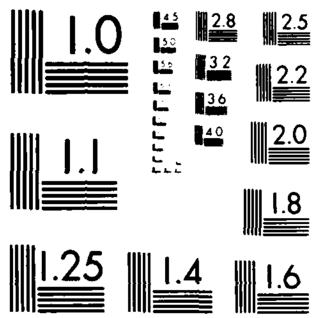

SOURIS RIVER AT BANTRY
FLOOD OF 1974
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30 day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS
(Thousands)
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
24FEB 10 20MAR 10 20 APR 10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30
TIME IN DAYS (BEGIN 24 JANUARY)
EXISTING
MODIFIED

PLATE D-13

AD-A189 263 SOURIS RIVER BASIN PROJECT SASKATCHEWAN CANADA - NORTH DAKOTA USA GENERAL..(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT NOV 87 5/5

UNCLASSIFIED F/G 13/2 NL

END
DATE
FILMED
8



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SOURIS RIVER AT WESTHOPE

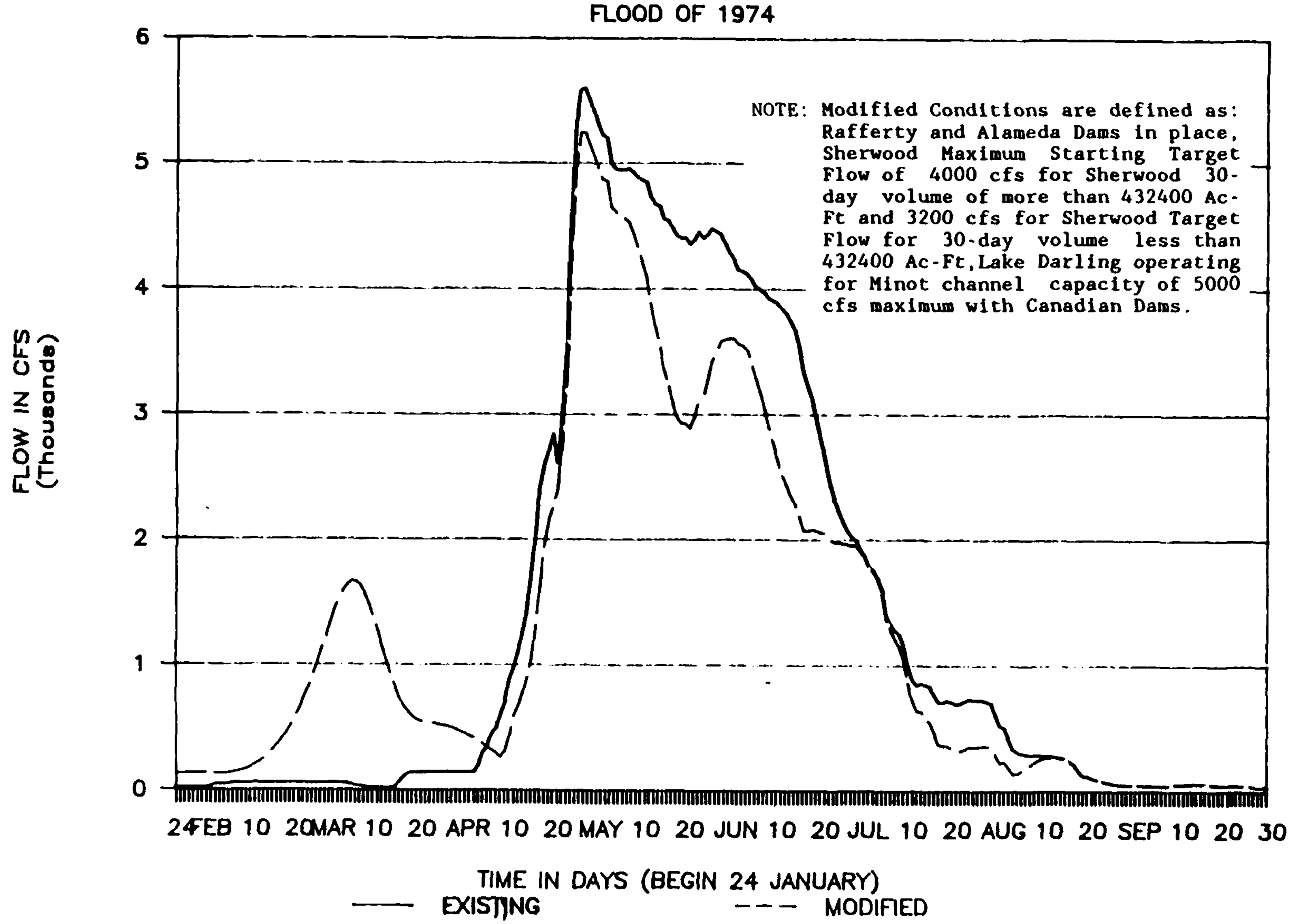


PLATE D-14

SOURIS RIVER AT SHERWOOD

FLOOD OF 1975

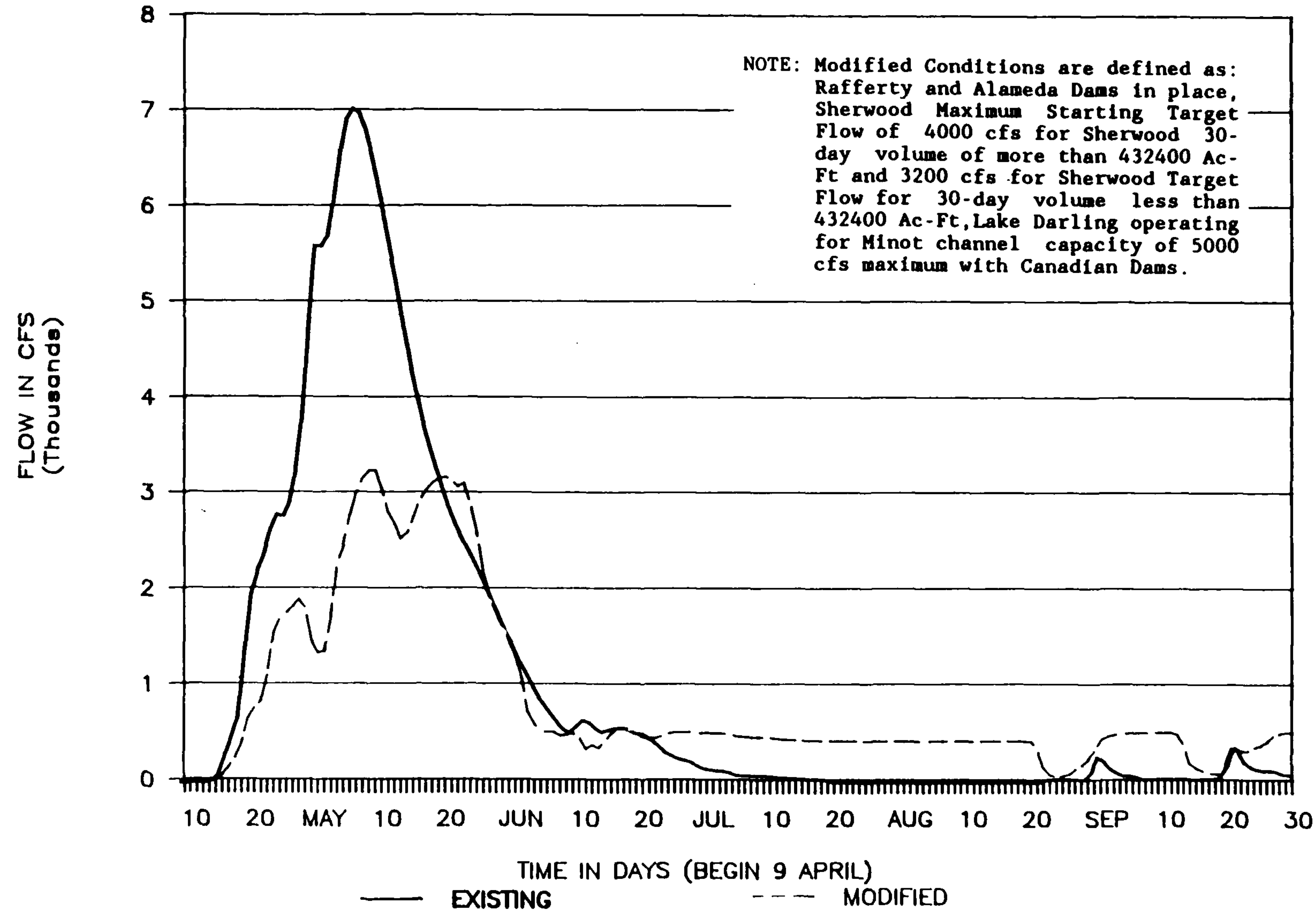
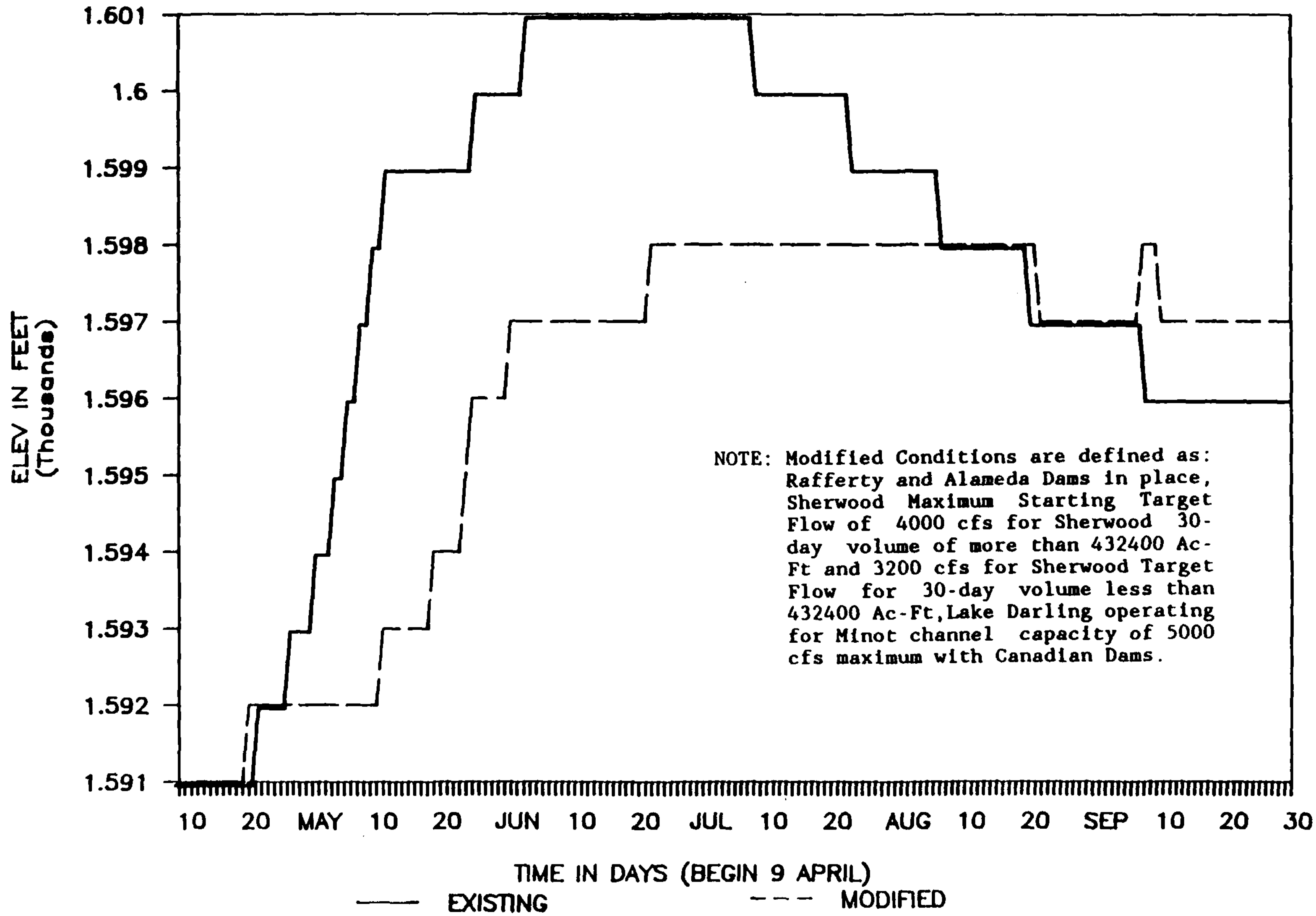


PLATE D-15

ELEVATION AT LAKE DARLING

FLOOD OF 1975



SOURIS RIVER AT FOXHOLM

FLOOD OF 1975

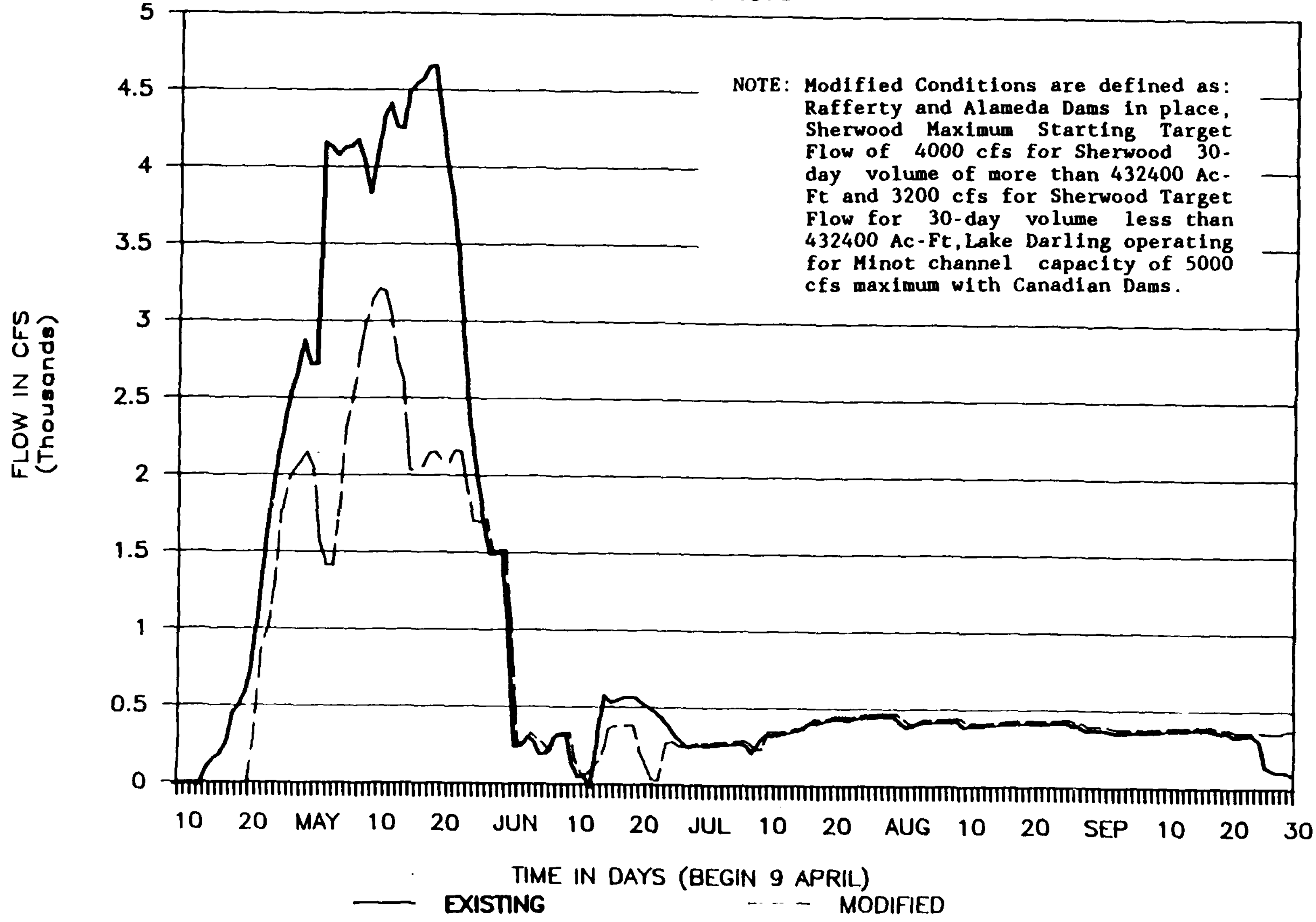
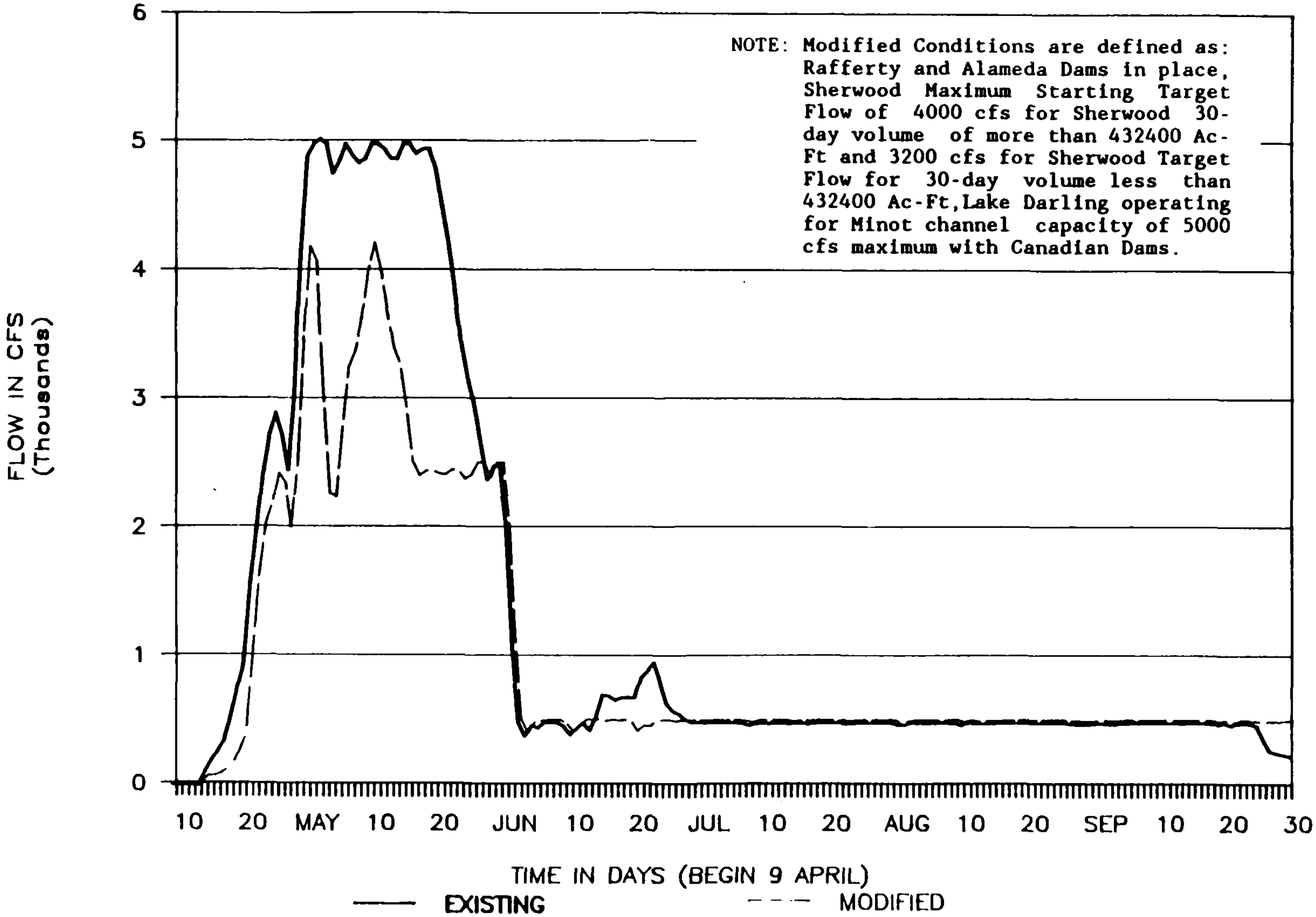


PLATE D-17

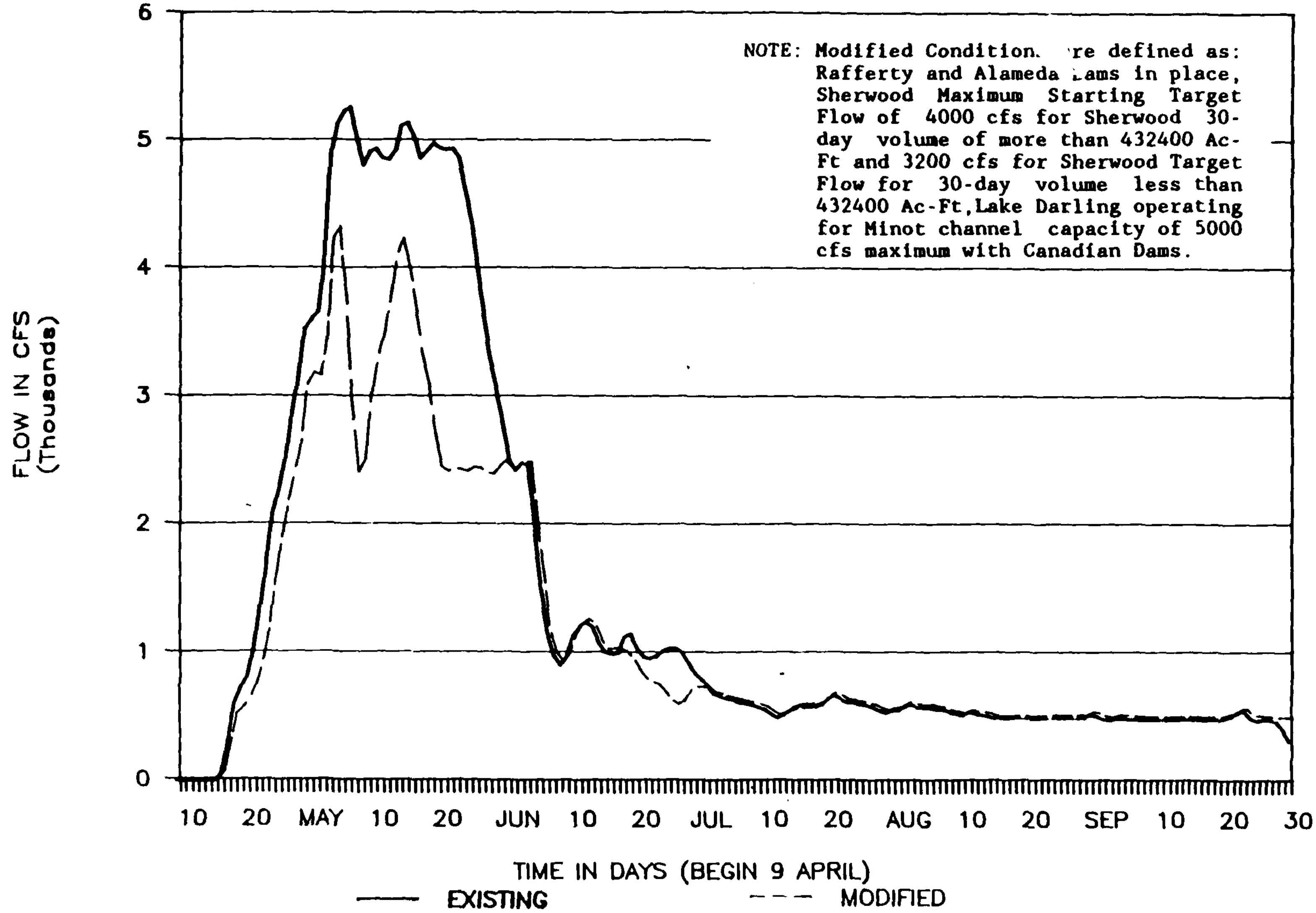
SOURIS RIVER AT MINOT

FLOOD OF 1975



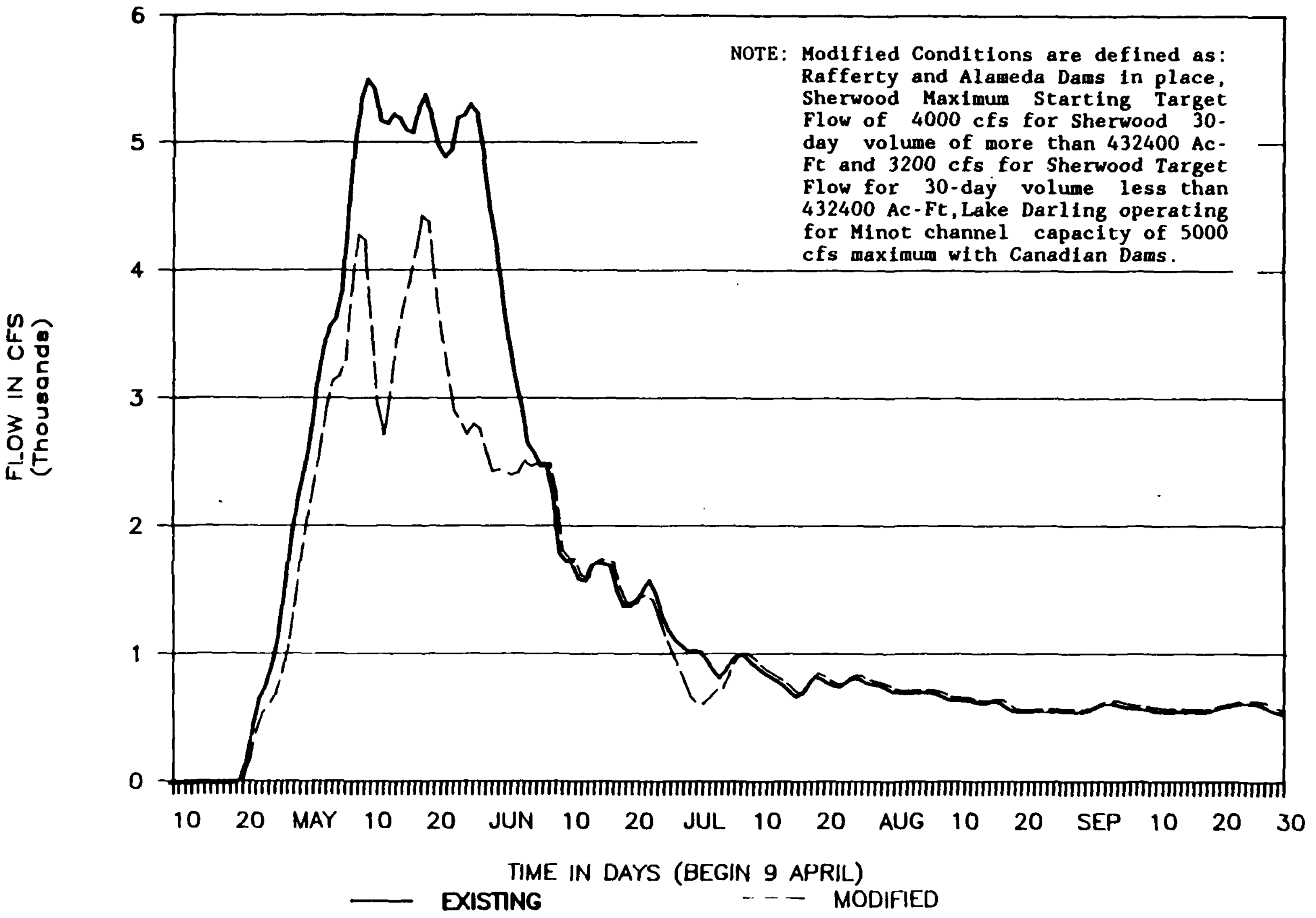
SOURIS RIVER AT VERENDRYE

FLOOD OF 1975



SOURIS RIVER AT BANTRY

FLOOD OF 1975



SOURIS RIVER AT WESTHOPE

FLOOD OF 1975

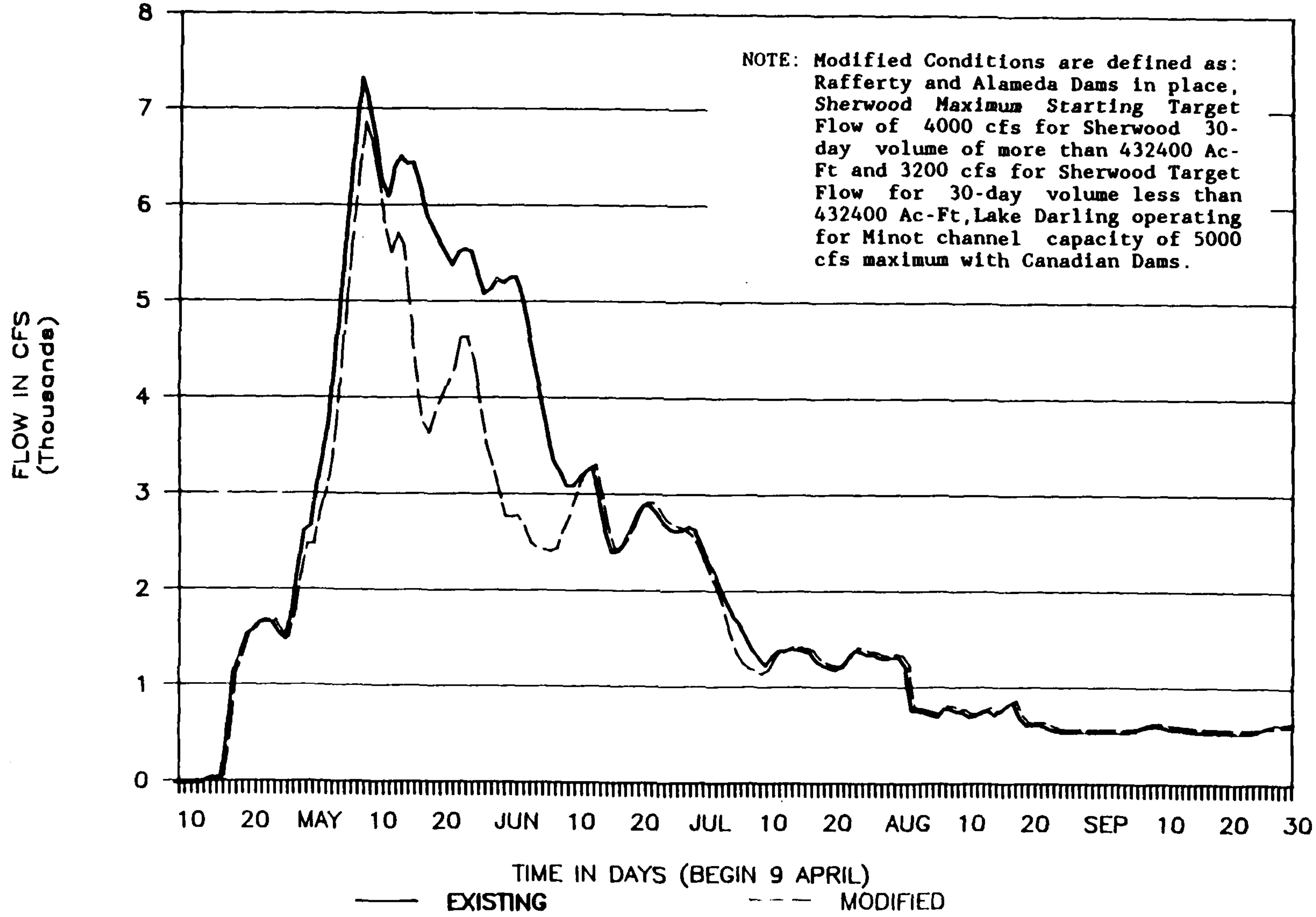
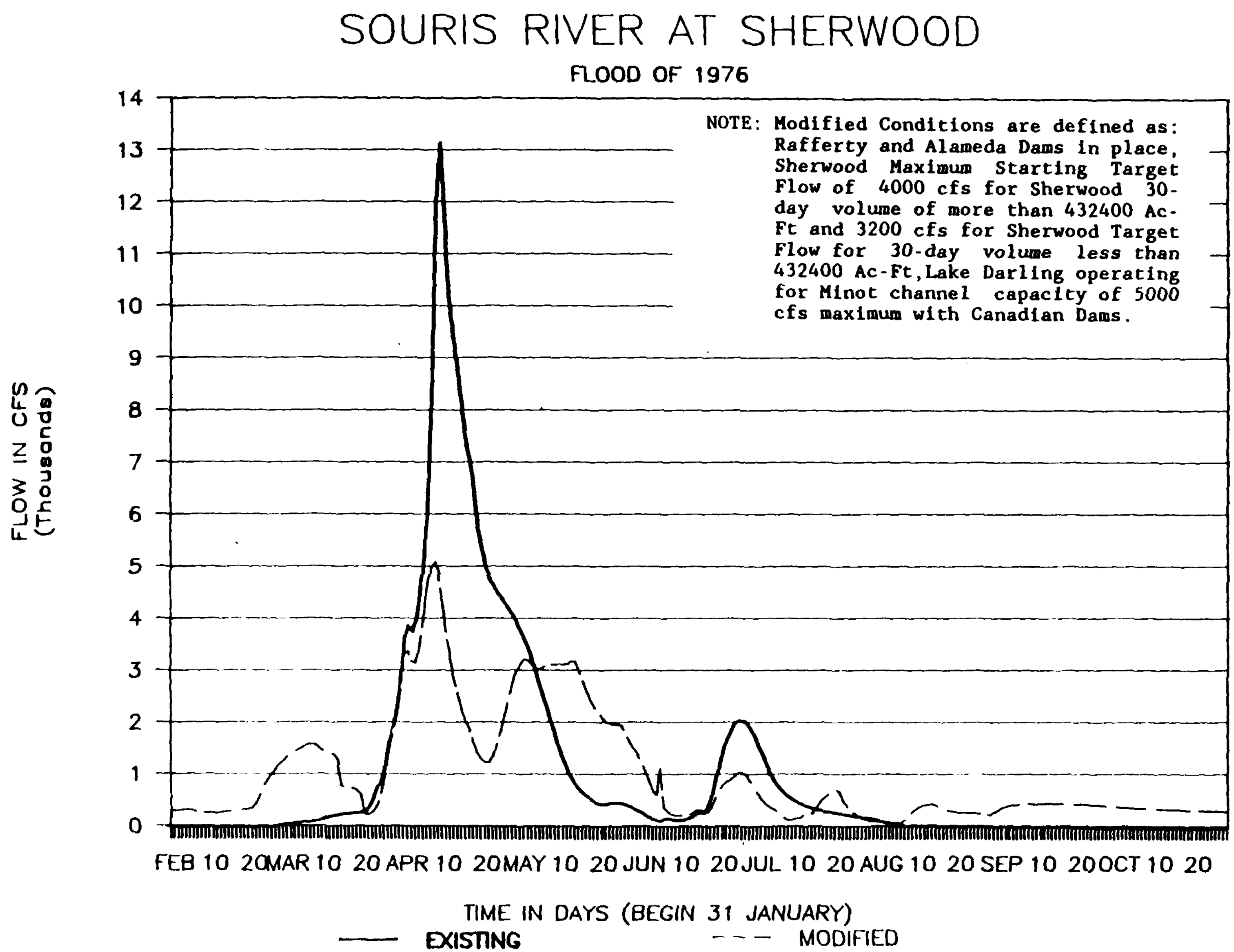
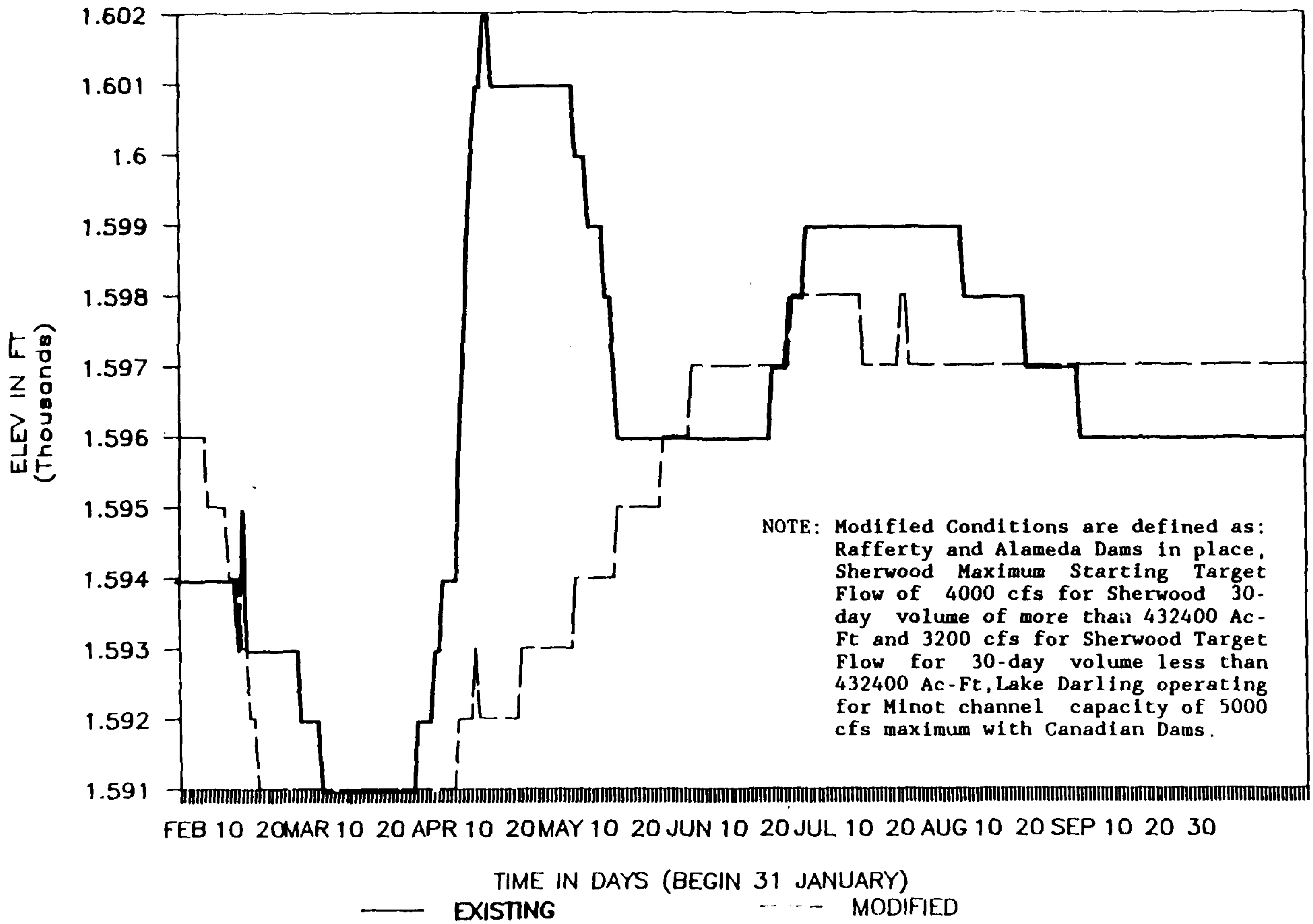


PLATE D-21


SOURIS RIVER AT SHERWOOD
FLOOD OF 1976
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
FEB 10 20 MAR 10 20 APR 10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 OCT 10 20
TIME IN DAYS (BEGIN 31 JANUARY)
EXISTING
MODIFIED

ELEVATION OF LAKE DARLING

FLOOD OF 1976



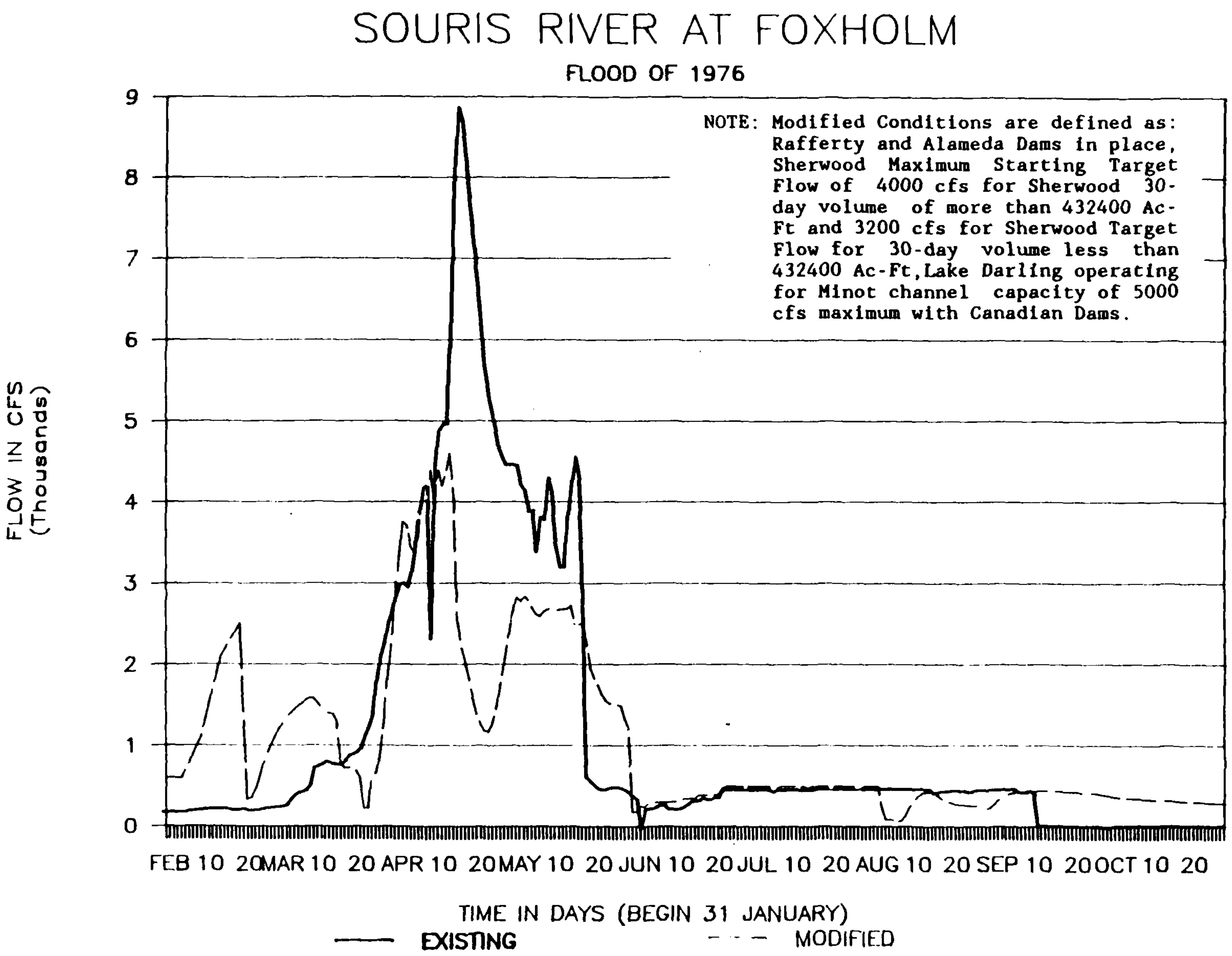
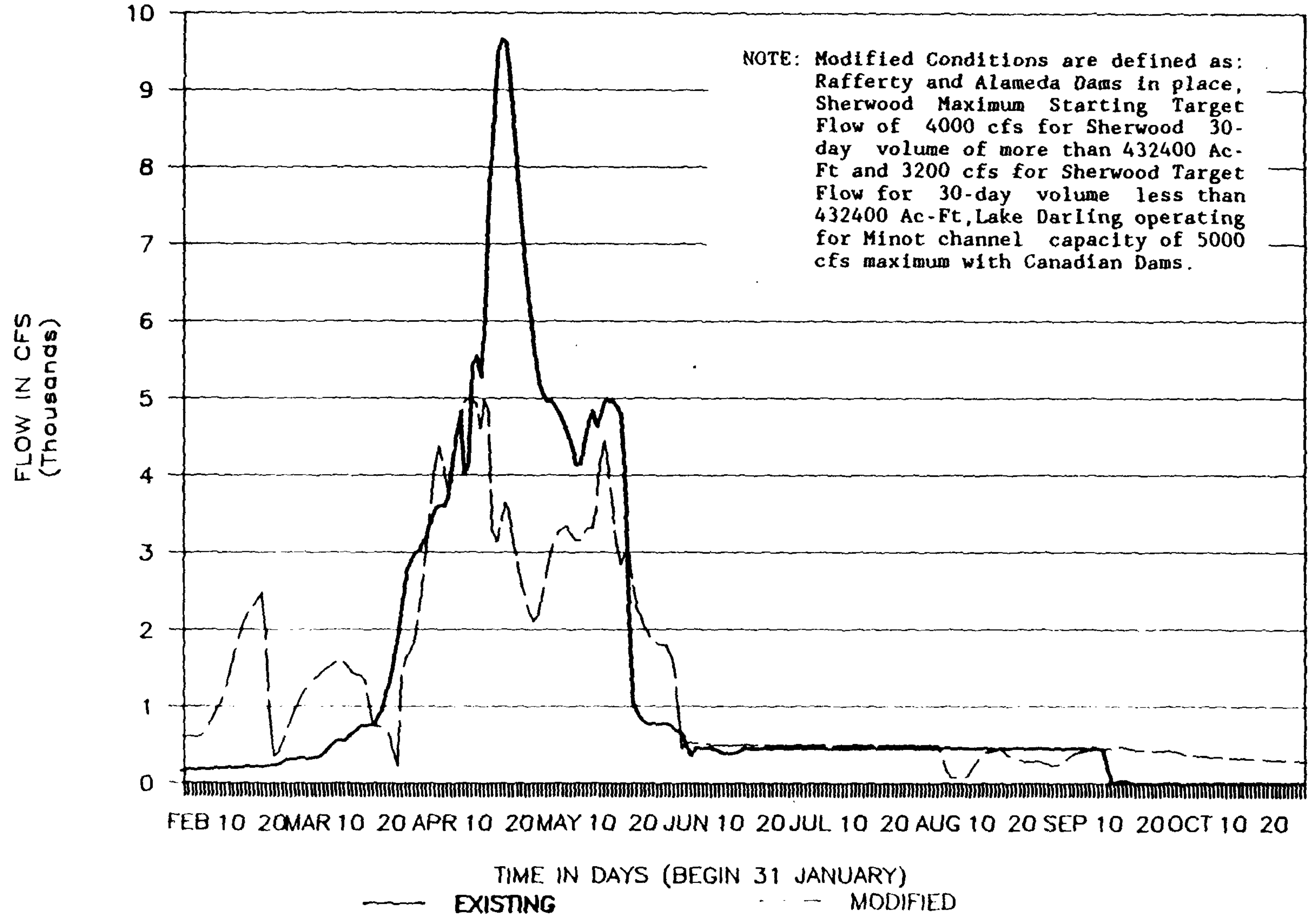
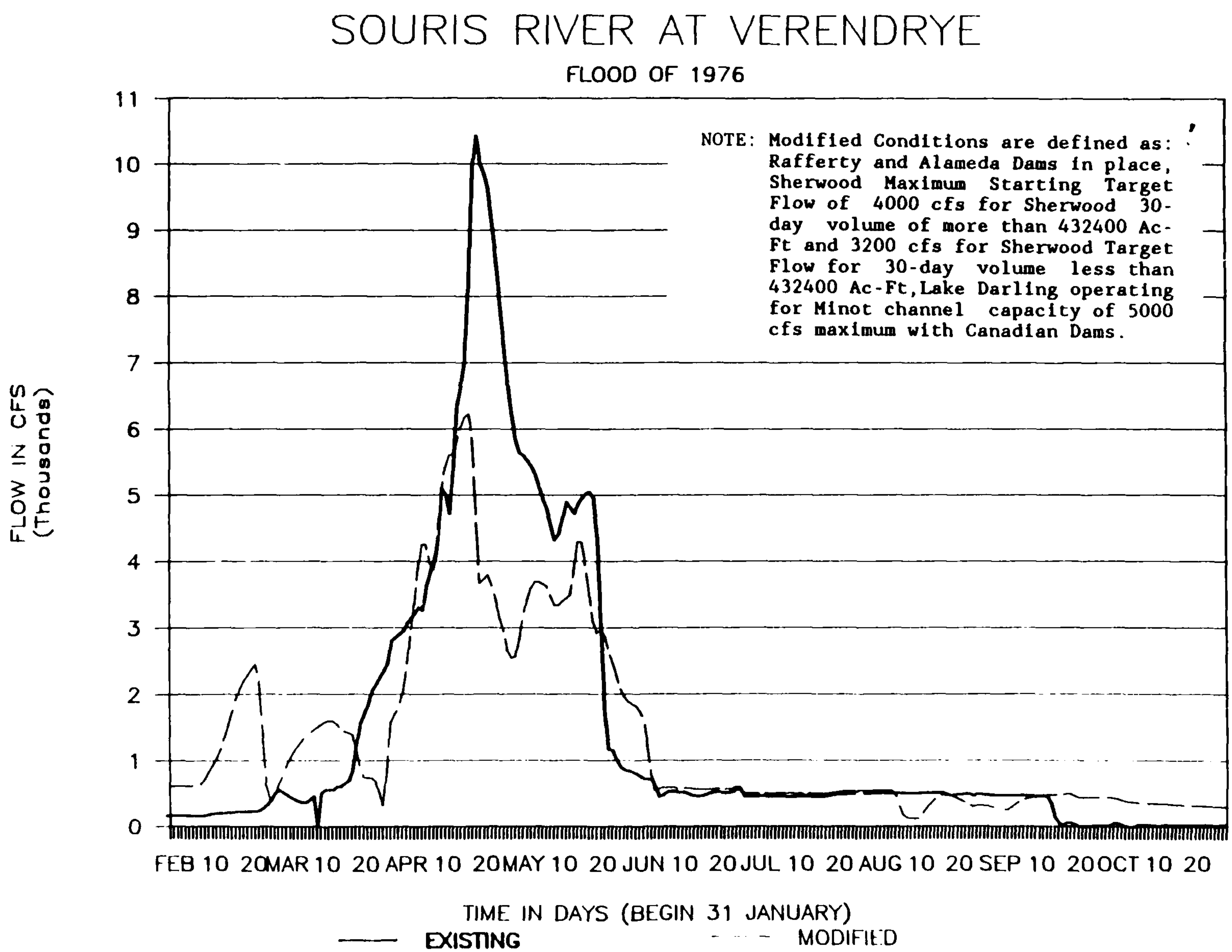

SOURIS RIVER AT FOXHOLM
FLOOD OF 1976
FLOW IN CFS (Thousands)
0
1
2
3
4
5
6
7
8
9
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FEB 10 20 MAR 10 20 APR 10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 OCT 10 20
TIME IN DAYS (BEGIN 31 JANUARY)
EXISTING
MODIFIED

PLATE D-24

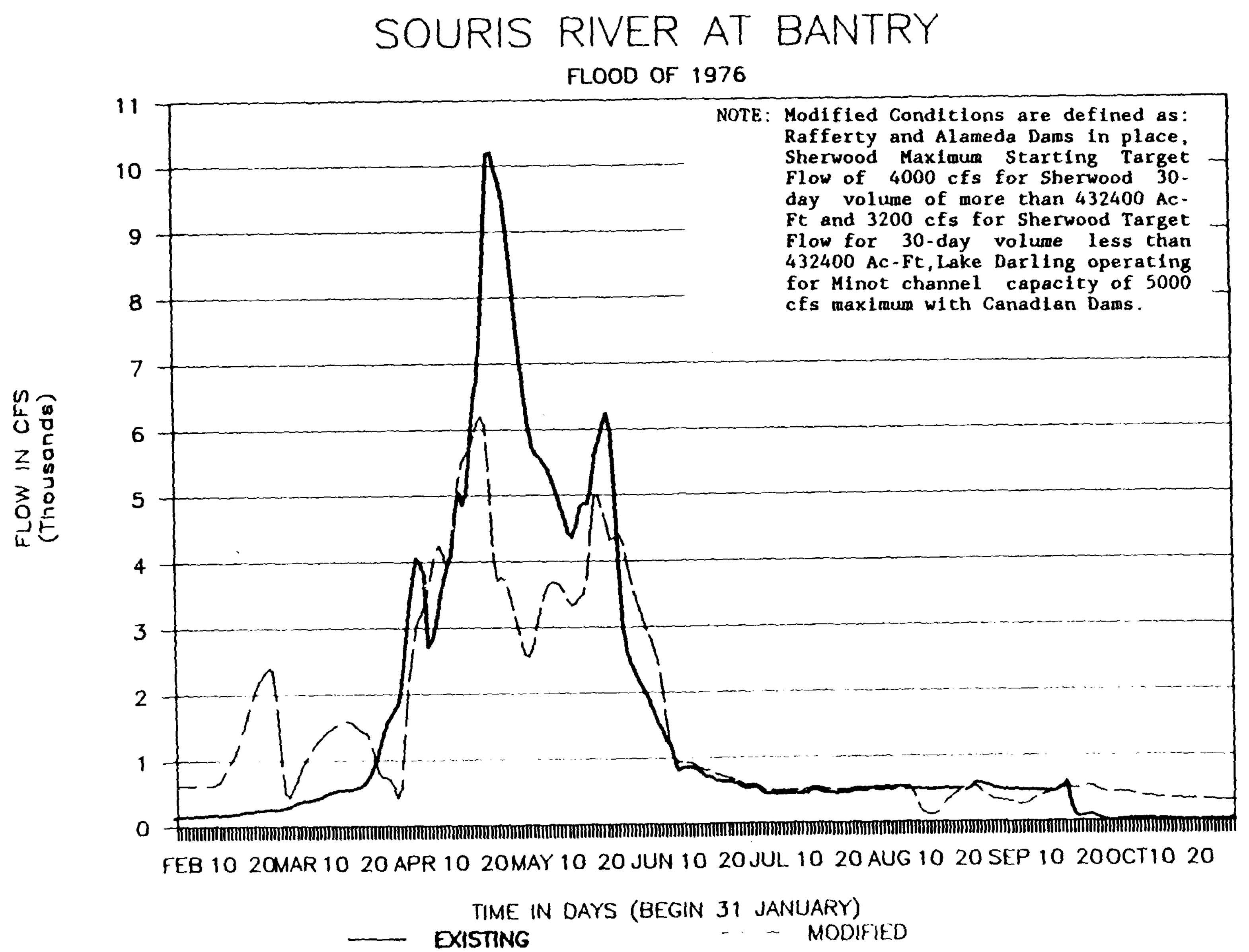
SOURIS RIVER AT MINOT

FLOOD OF 1976





SOURIS RIVER AT VERENDRYE
FLOOD OF 1976
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
0 1 2 3 4 5 6 7 8 9 10 11
FEB 10 20 MAR 10 20 APR 10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 OCT 10 20
TIME IN DAYS (BEGIN 31 JANUARY)
EXISTING
MODIFIED


SOURIS RIVER AT BANTRY
FLOOD OF 1976
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
FEB 10 20 MAR 10 20 APR 10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 OCT 10 20
TIME IN DAYS (BEGIN 31 JANUARY)
EXISTING
MODIFIED

SOURIS RIVER AT WESTHOPE

FLOOD OF 1976

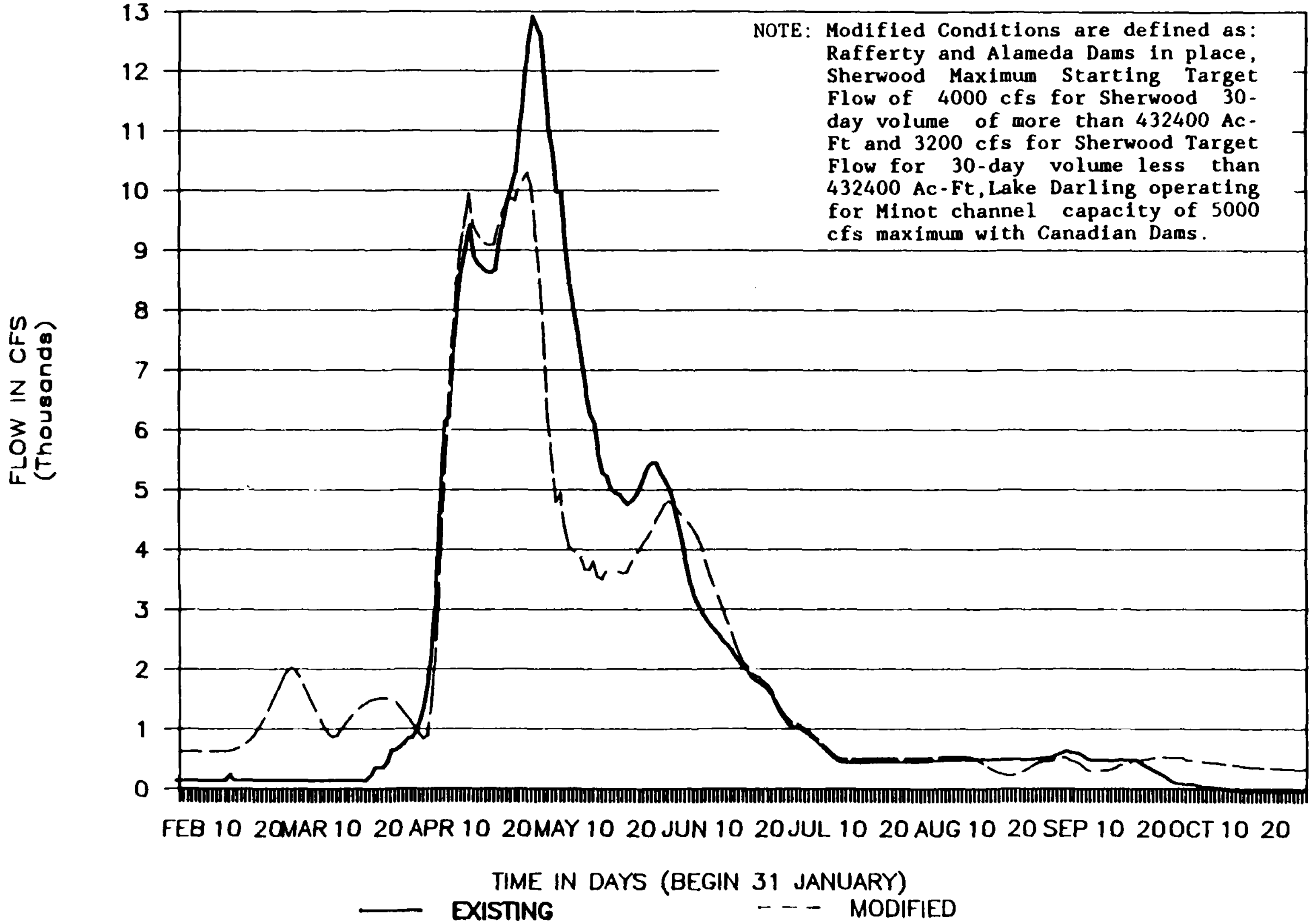


PLATE D-28

SOURIS RIVER AT SHERWOOD

FLOOD OF 1979

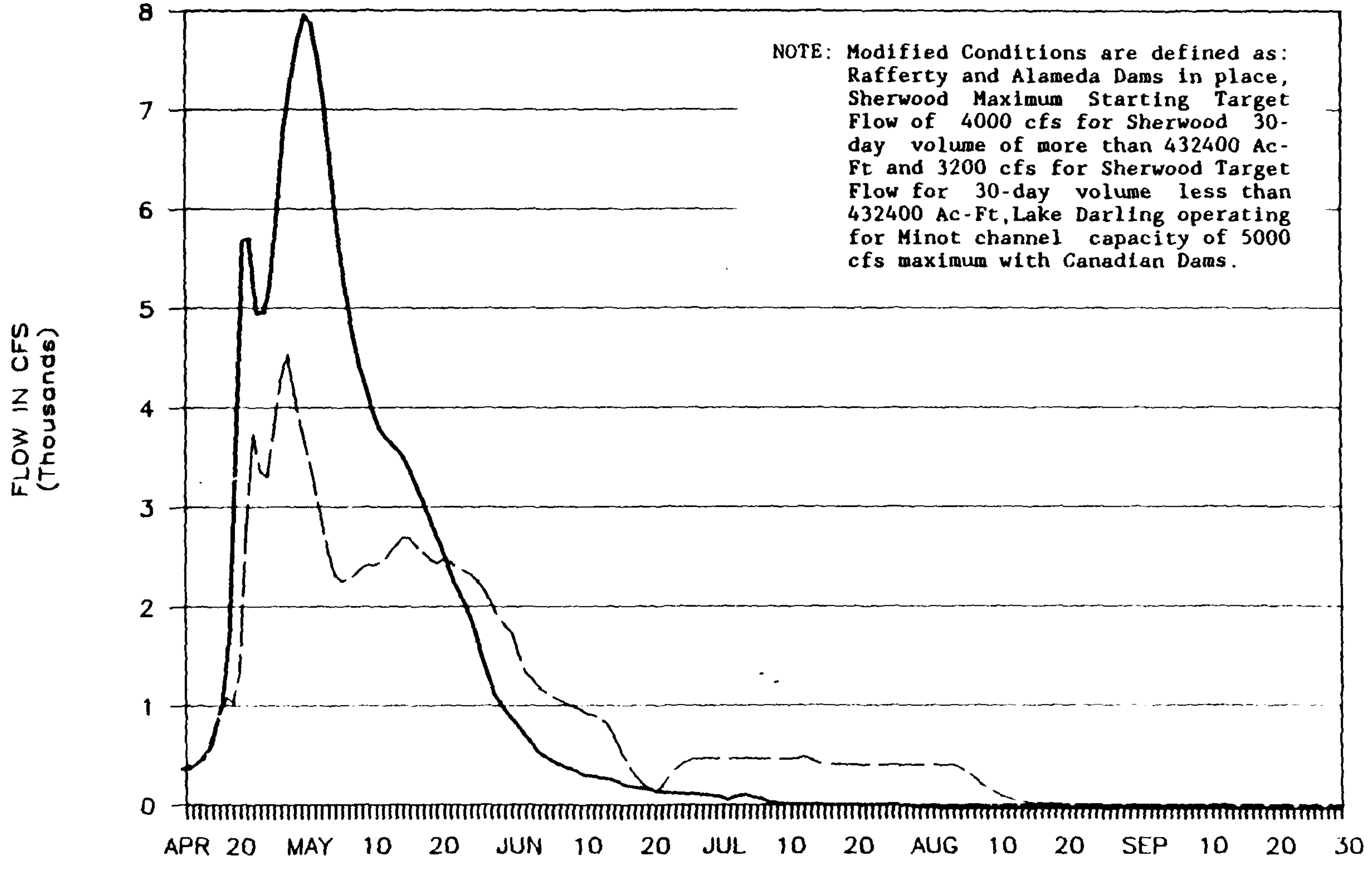
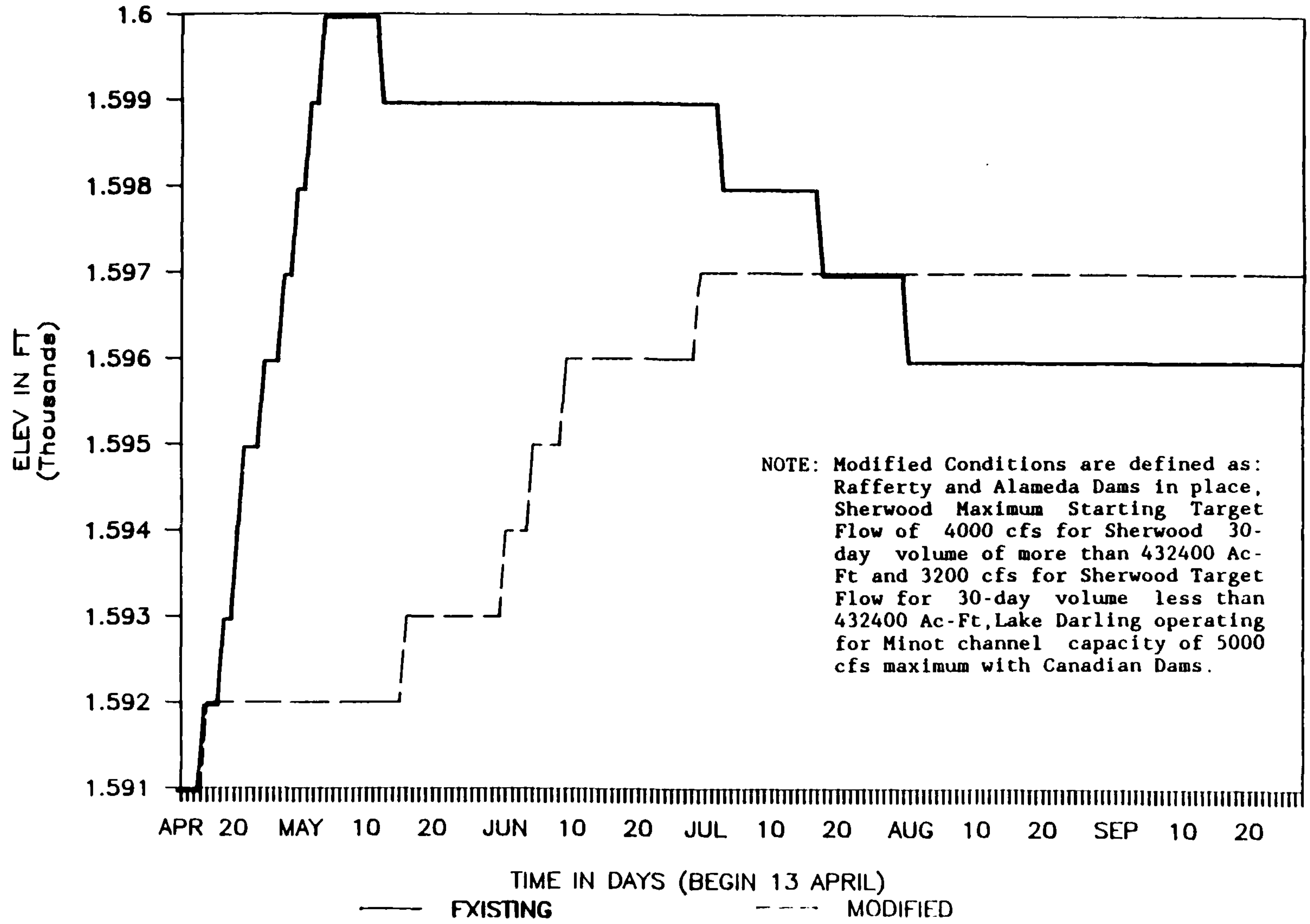


PLATE D-29

ELEVATIONS AT LAKE DARLING

FLOOD OF 1979



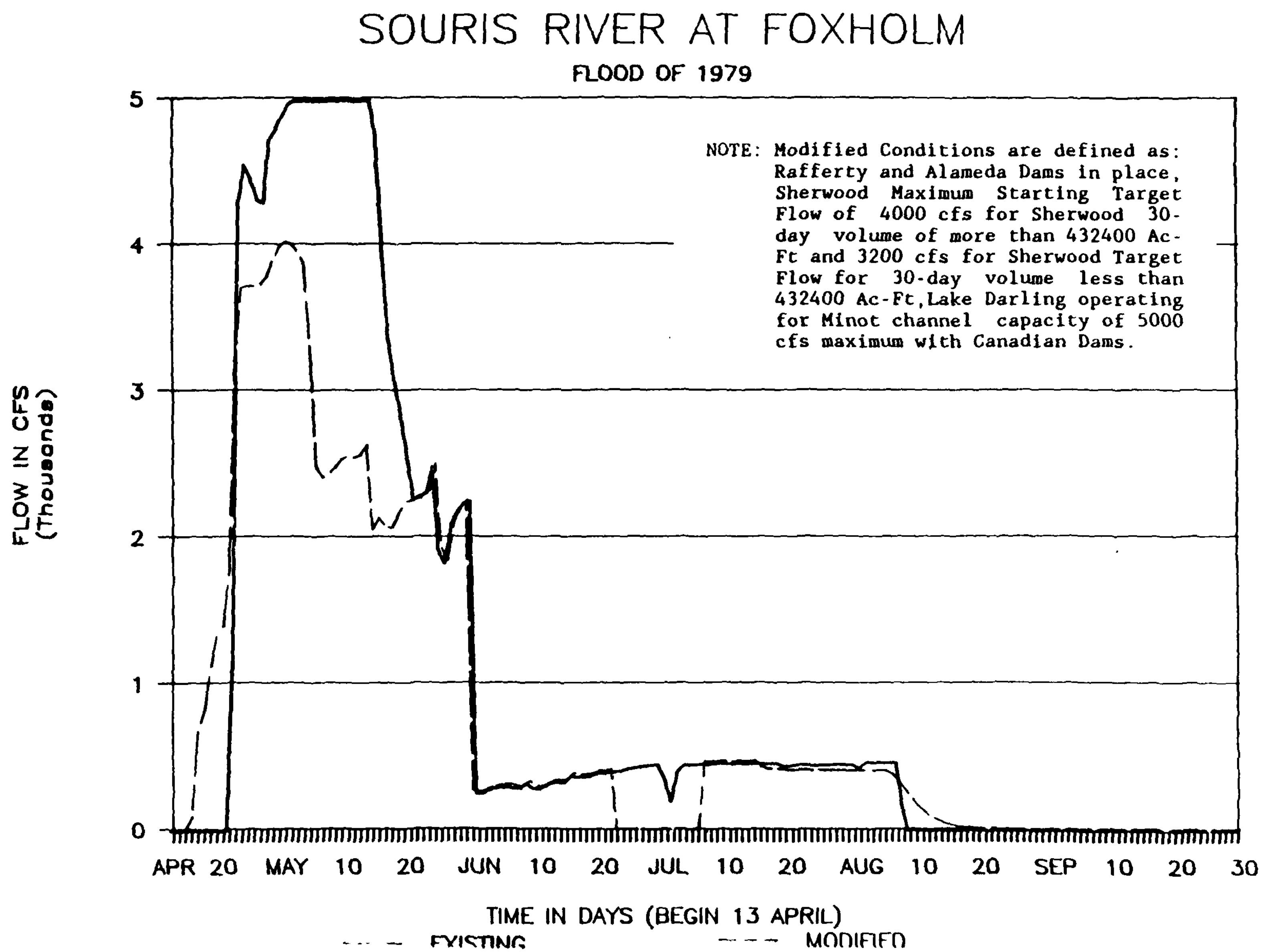

SOURIS RIVER AT FOXHOLM
FLOOD OF 1979
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
5
4
3
2
1
0
APR 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30
TIME IN DAYS (BEGIN 13 APRIL)
EXISTING
MODIFIED

PLATE D-31

SOURIS RIVER AT MINOT

FLOOD OF 1979

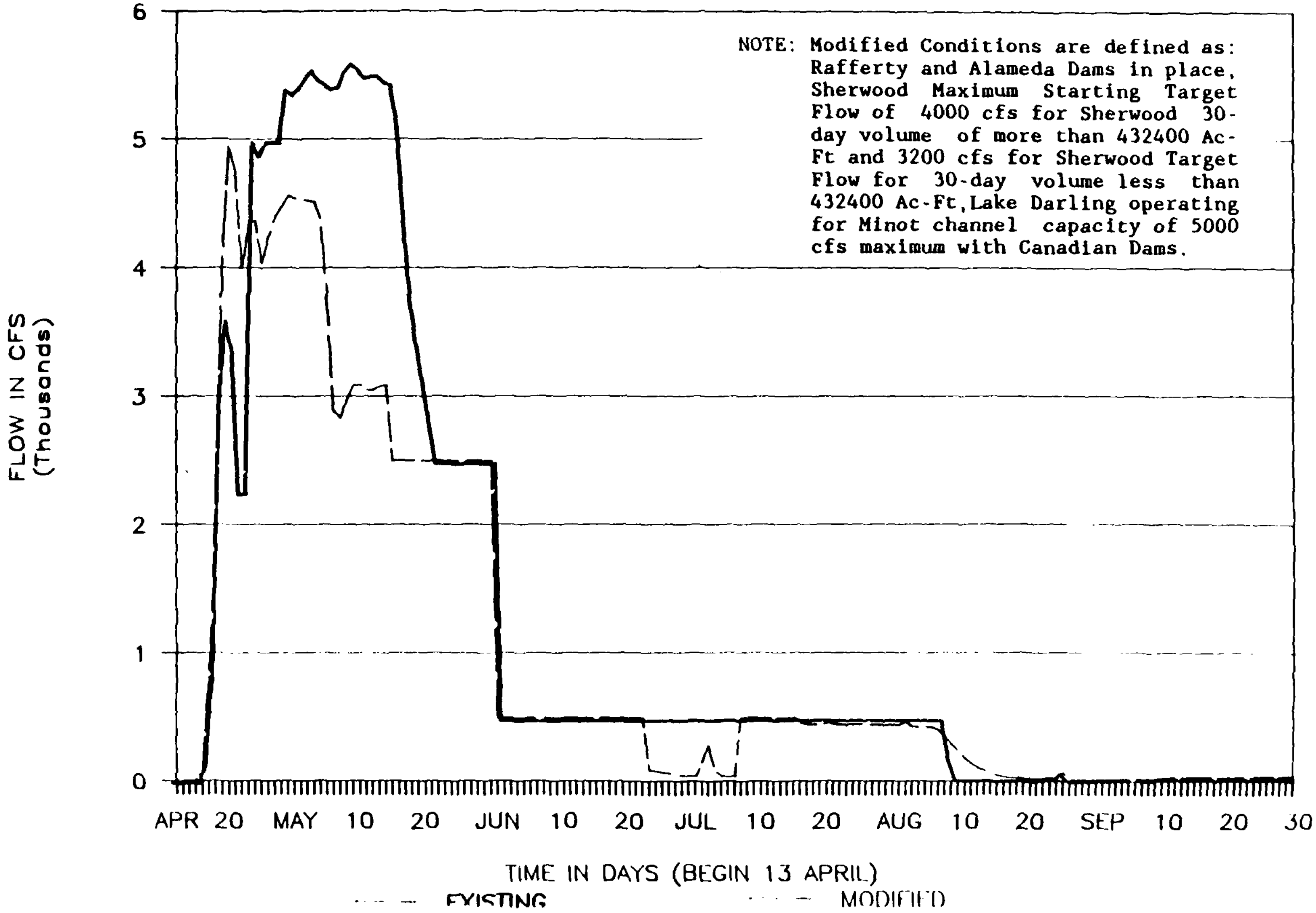
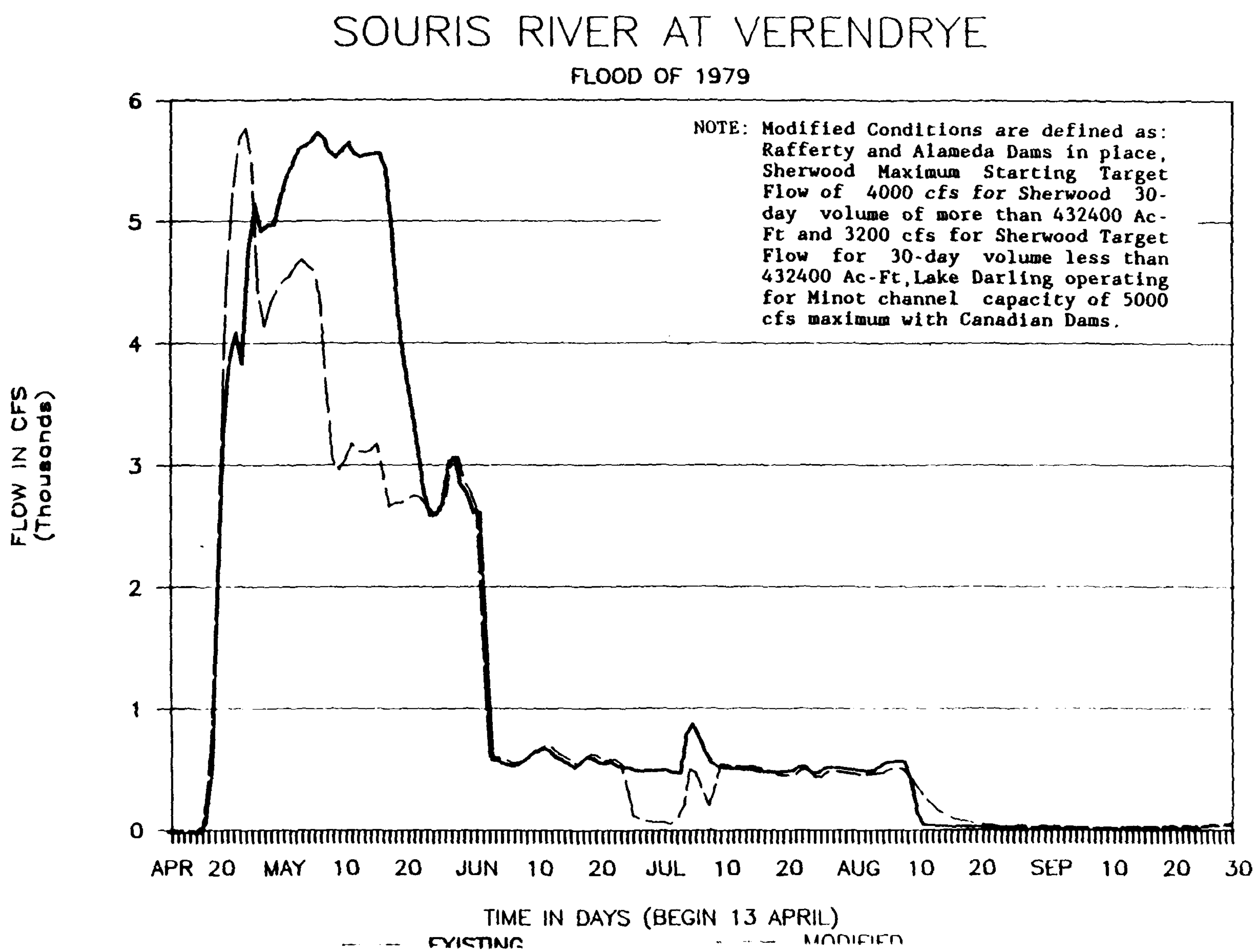


PLATE D-32


SOURIS RIVER AT VERENDRYE
FLOOD OF 1979
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
0
1
2
3
4
5
6
APR 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30
TIME IN DAYS (BEGIN 13 APRIL)

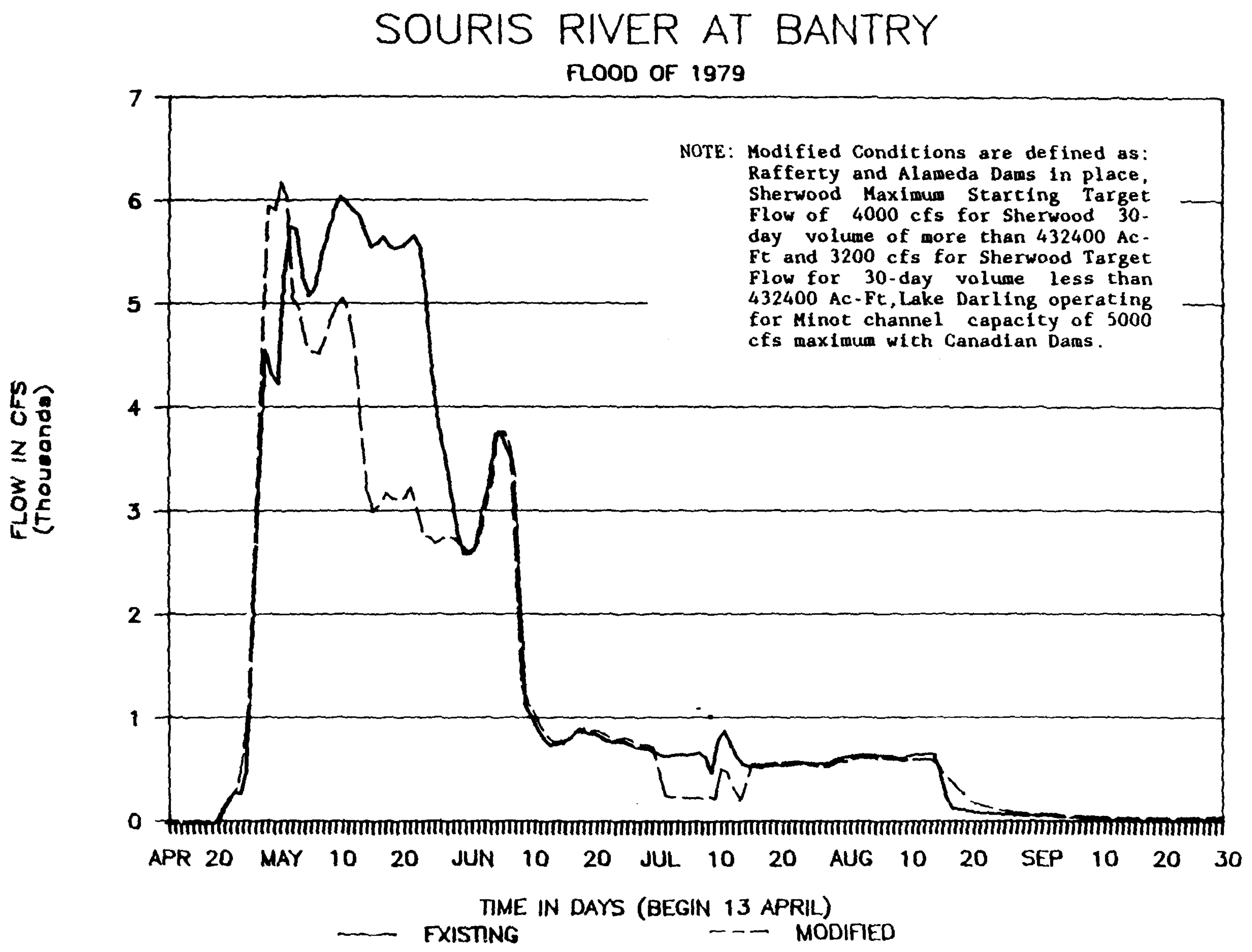
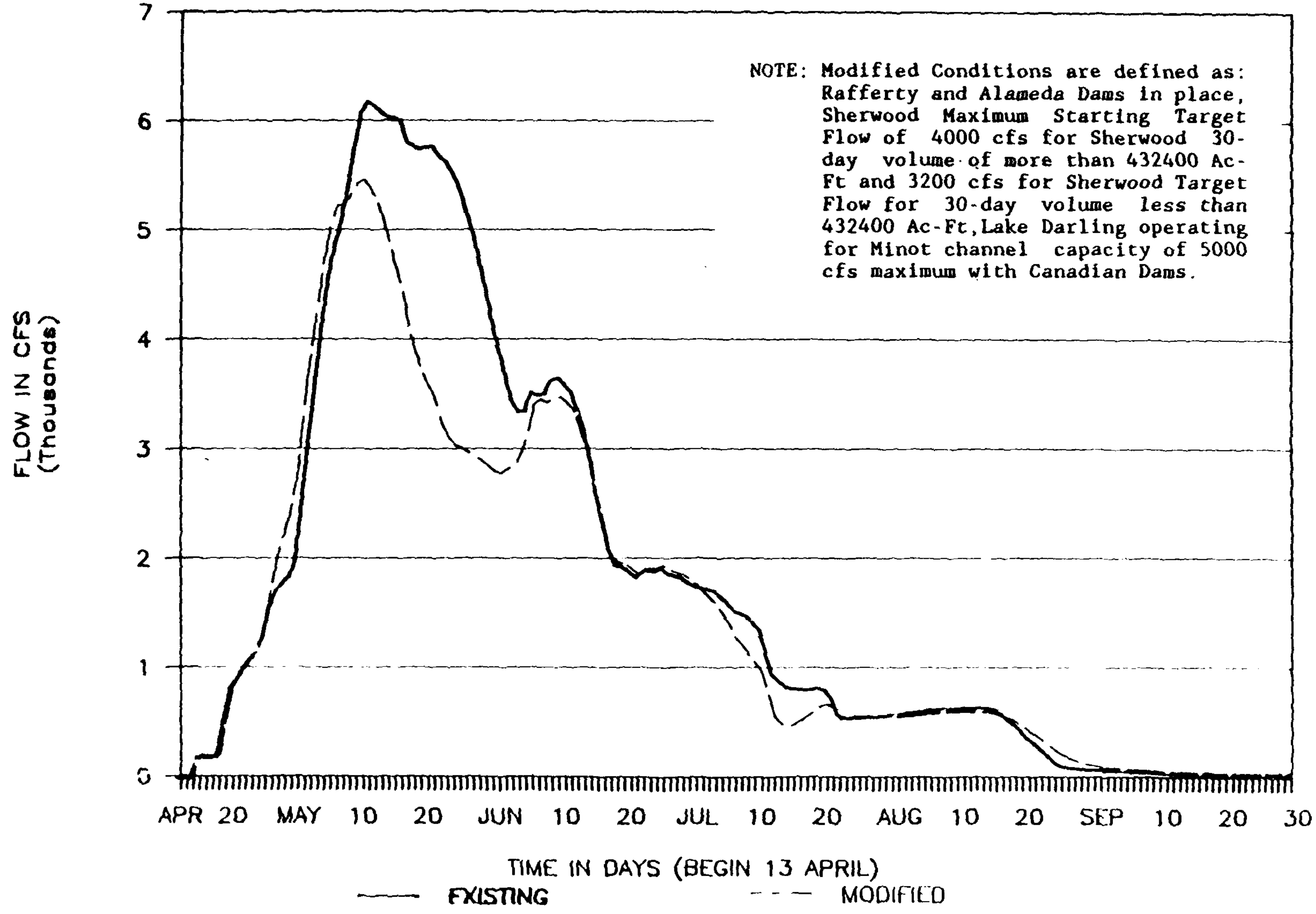

SOURIS RIVER AT BANTRY
FLOOD OF 1979
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
0
1
2
3
4
5
6
7
APR 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30
TIME IN DAYS (BEGIN 13 APRIL)
FXISTING
MODIFIED

PLATE D-34

SOURIS RIVER AT WESTHOPE

FLOOD OF 1979



SOURIS RIVER AT SHERWOOD

FLOOD OF 1982

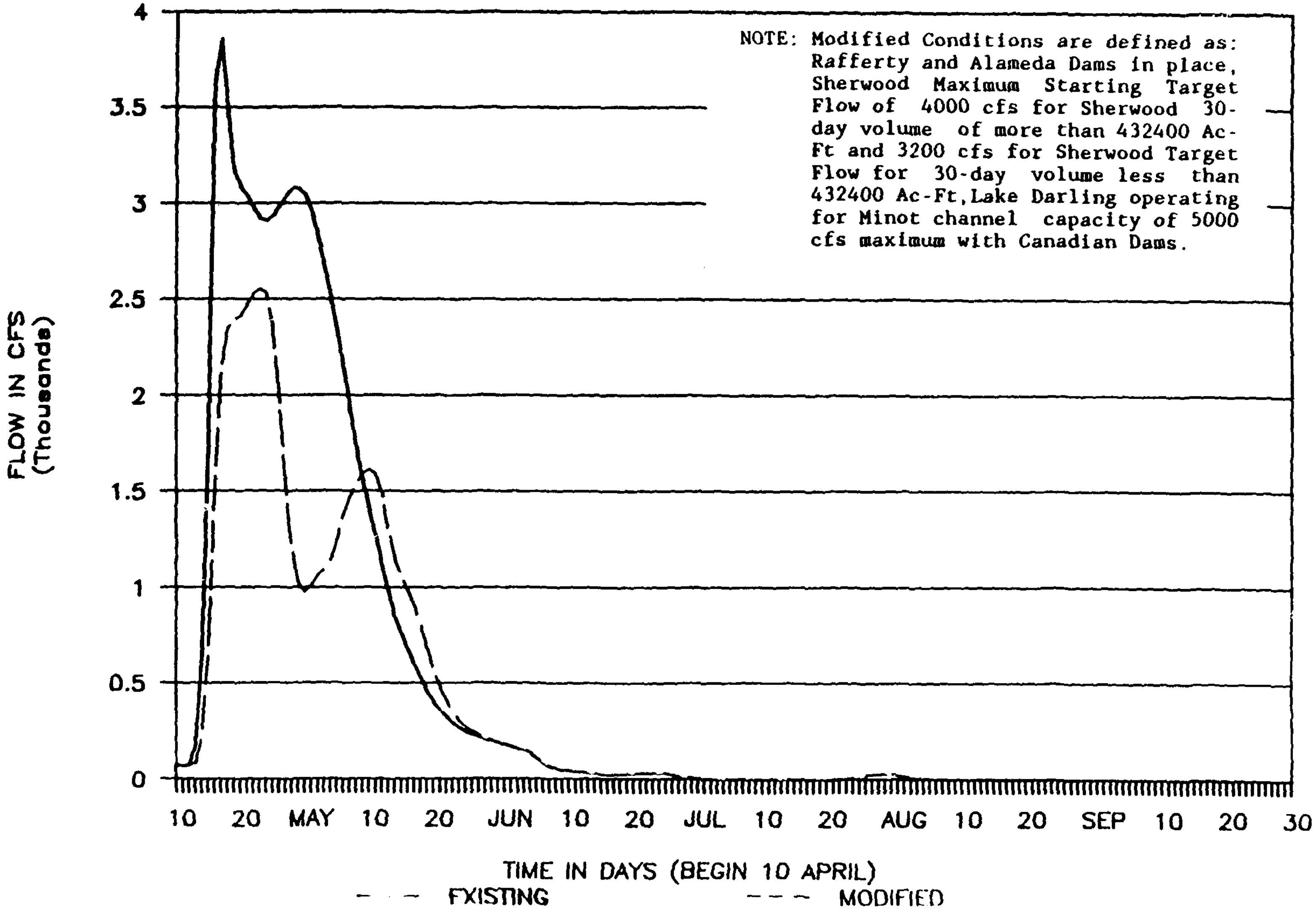
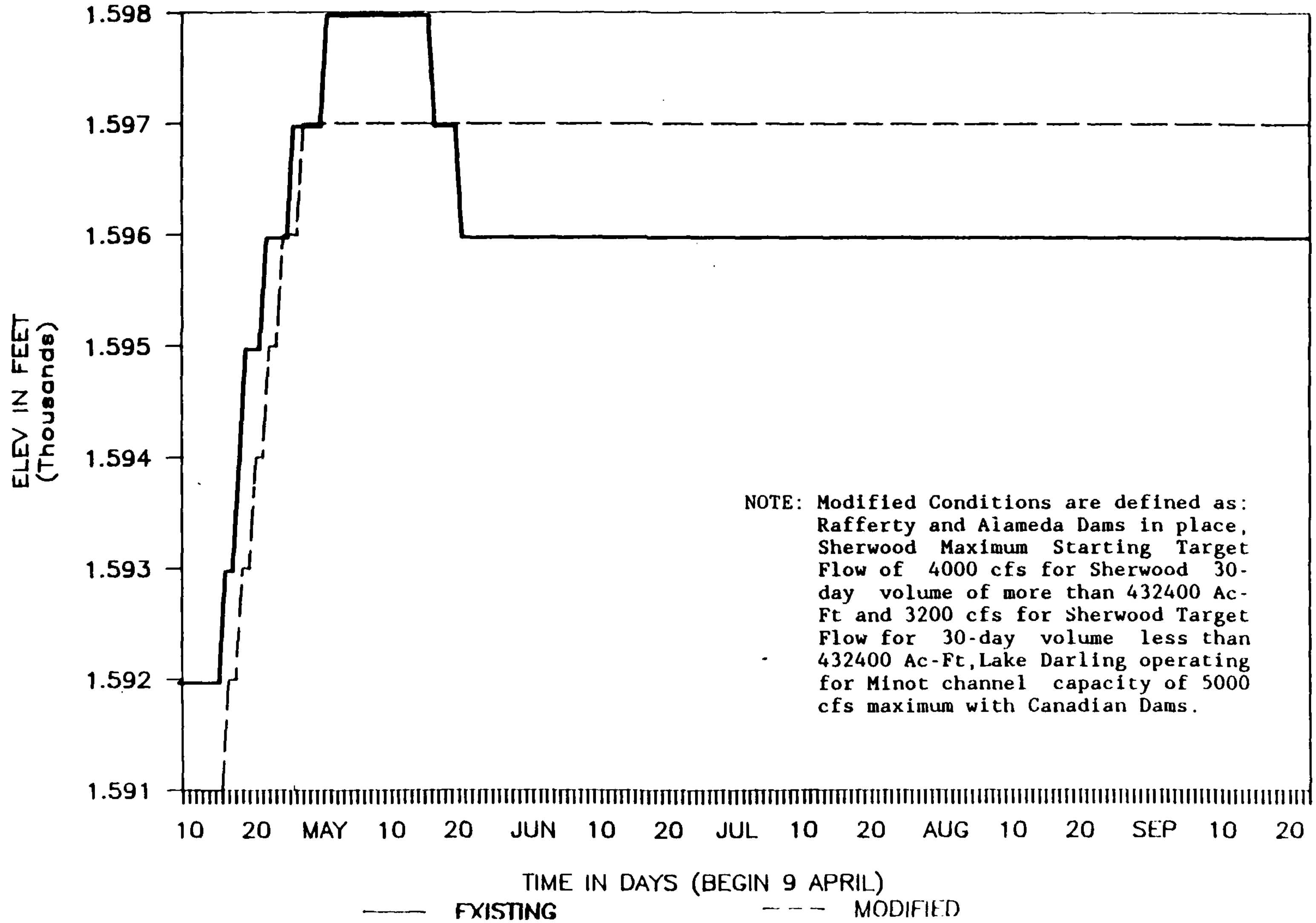
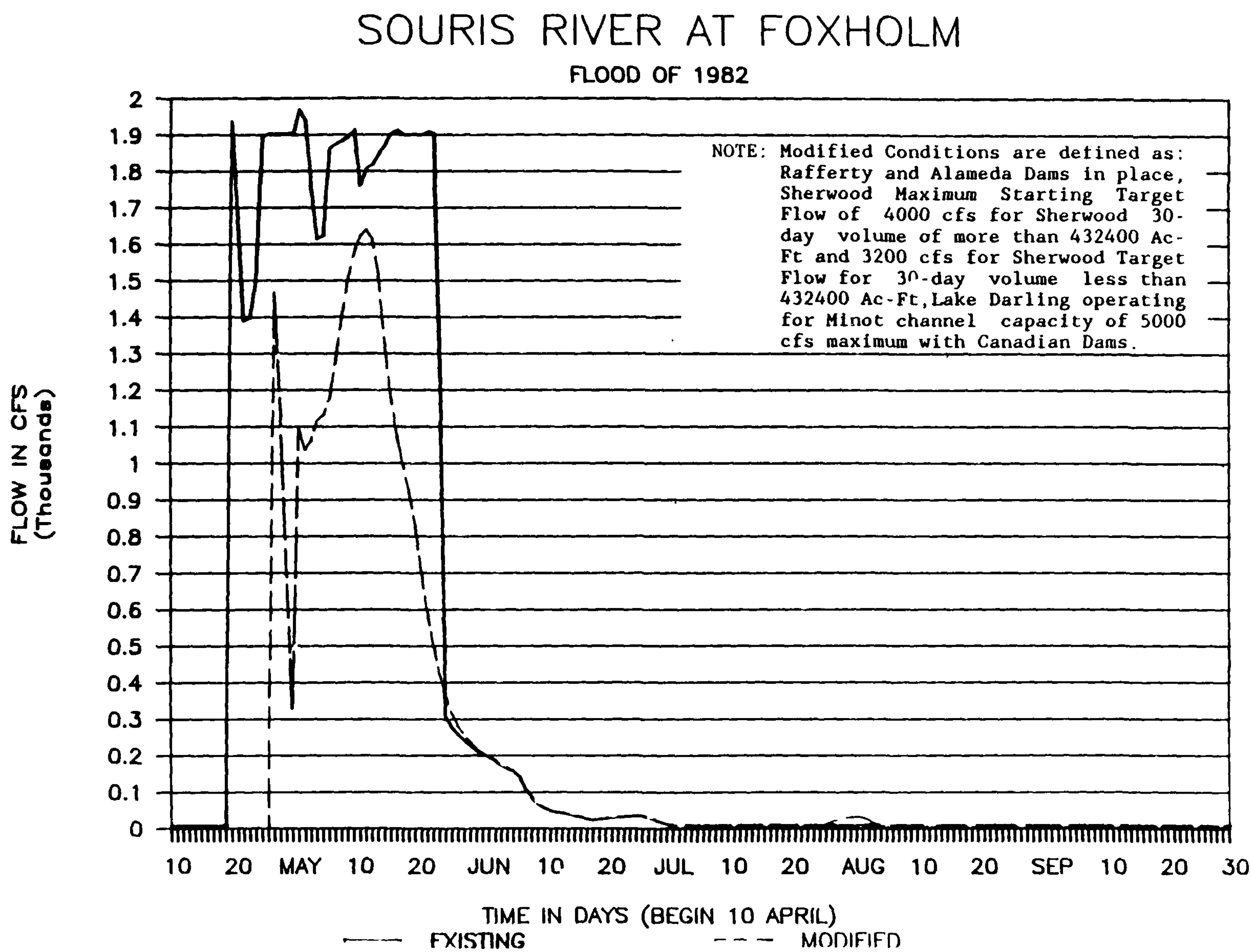


PLATE D-36

ELEVATION AT LAKE DARLING

FLOOD OF 1982





SOURIS RIVER AT FOXHOLM
FLOOD OF 1982
FLOW IN CFS (Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30
TIME IN DAYS (BEGIN 10 APRIL)
EXISTING
MODIFIED
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.

PLATE D-38

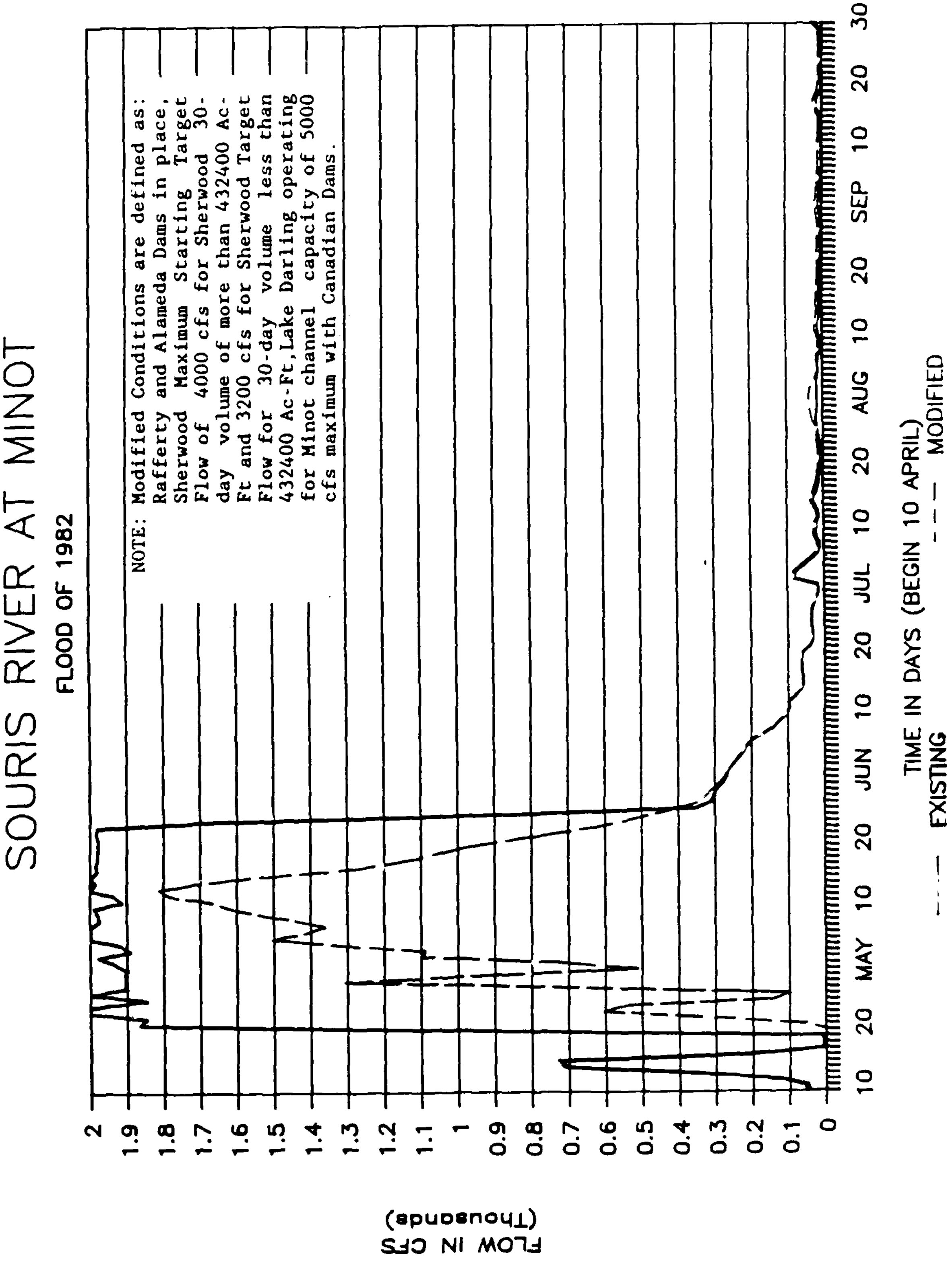

SOURIS RIVER AT MINOT
FLOOD OF 1982
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30
TIME IN DAYS (BEGIN 10 APRIL)
EXISTING
MODIFIED

PLATE D-39

SOURIS RIVER AT VERENDRYE

FLOOD OF 1982

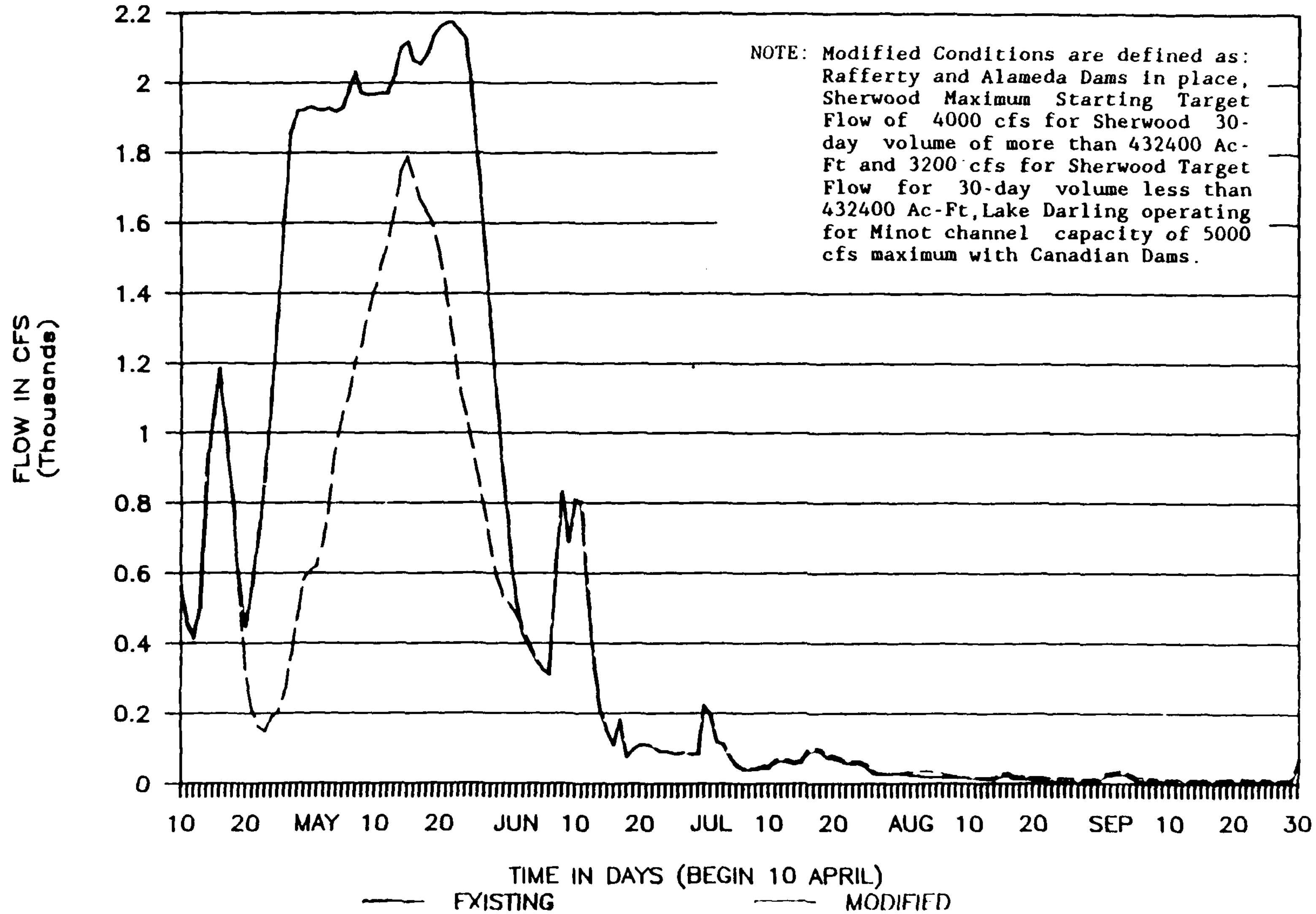
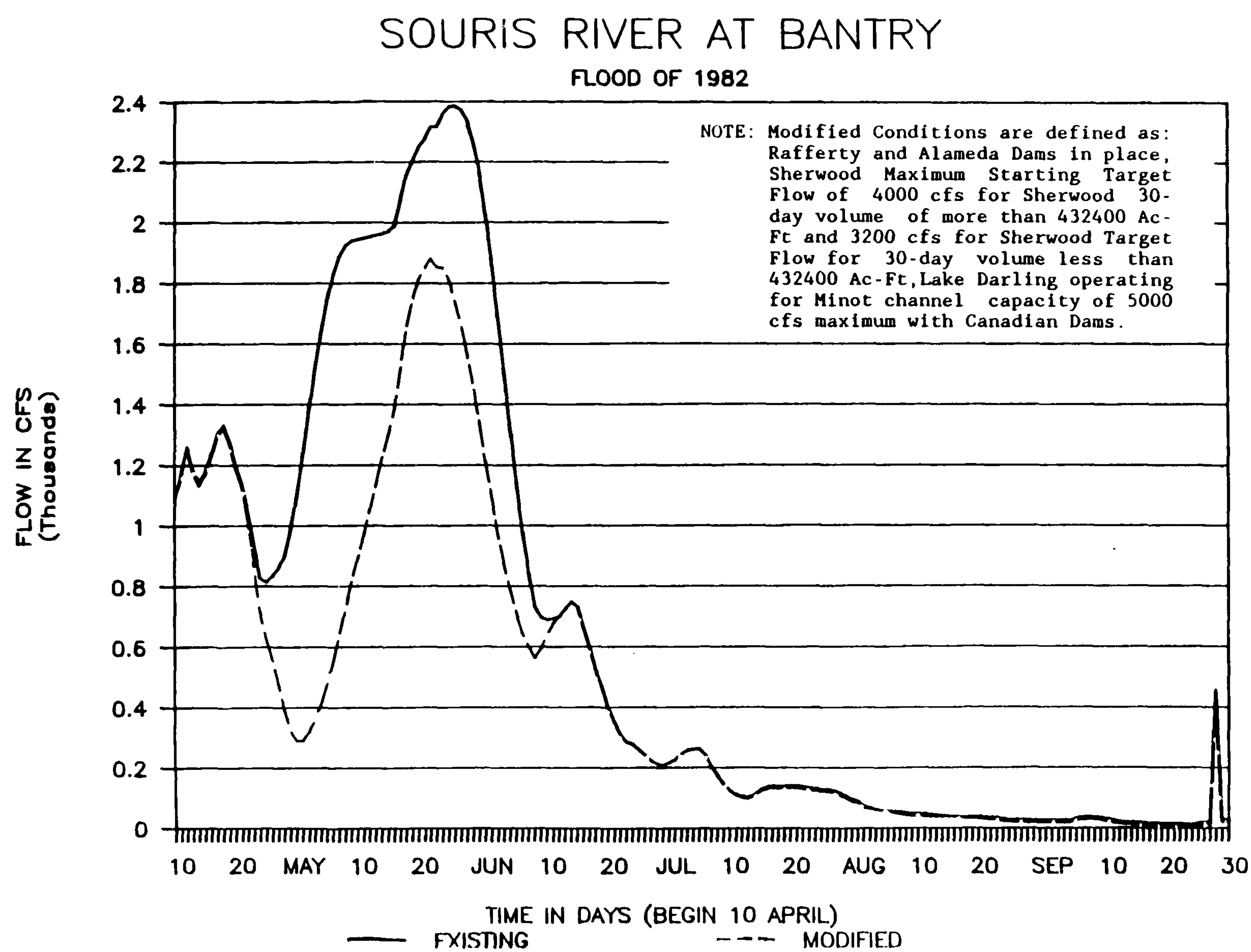
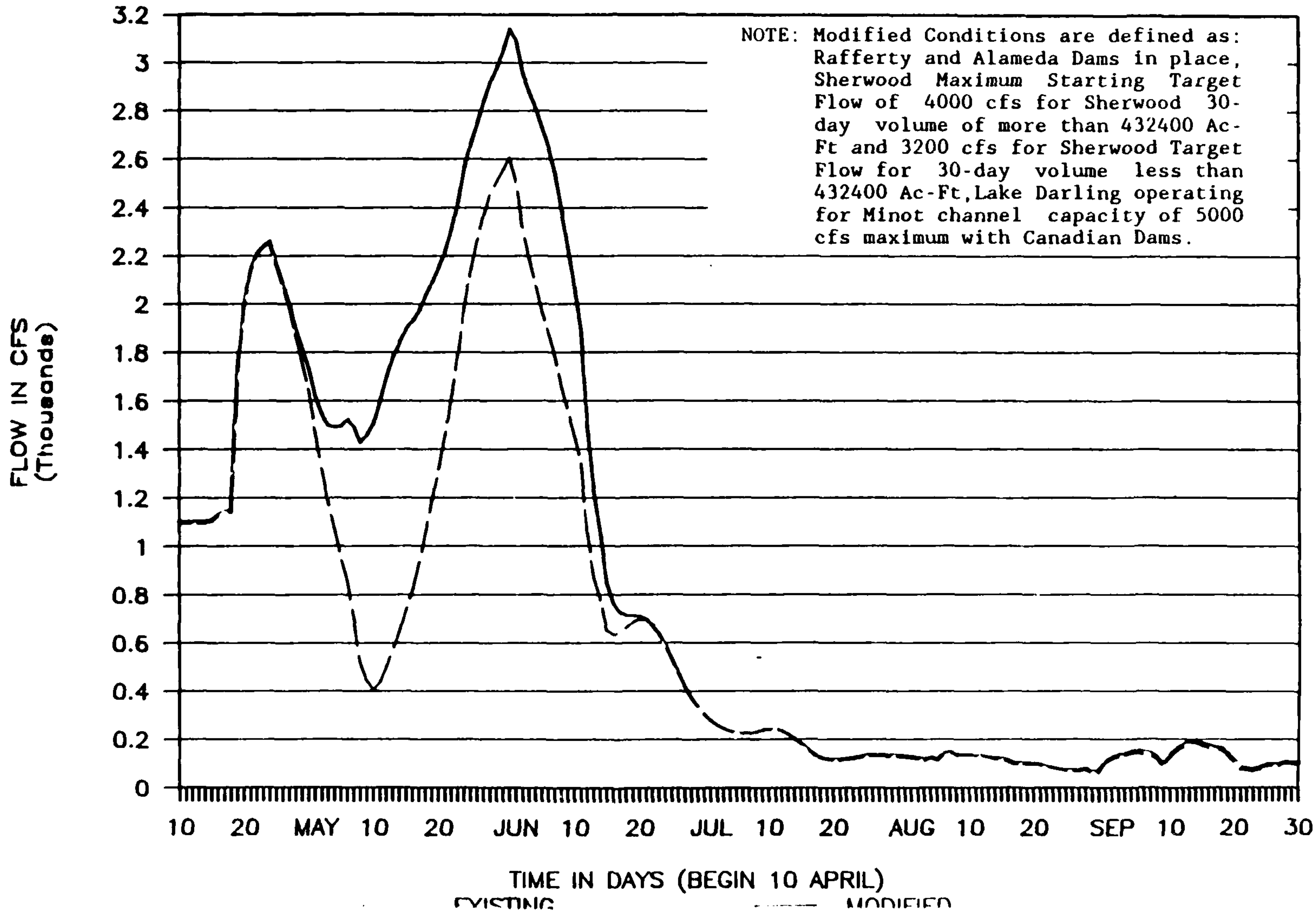


PLATE D-40


SOURIS RIVER AT BANTRY
FLOOD OF 1982
FLOW IN CFS (Thousands)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
10 20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30
TIME IN DAYS (BEGIN 10 APRIL)
FXISTING
MODIFIED

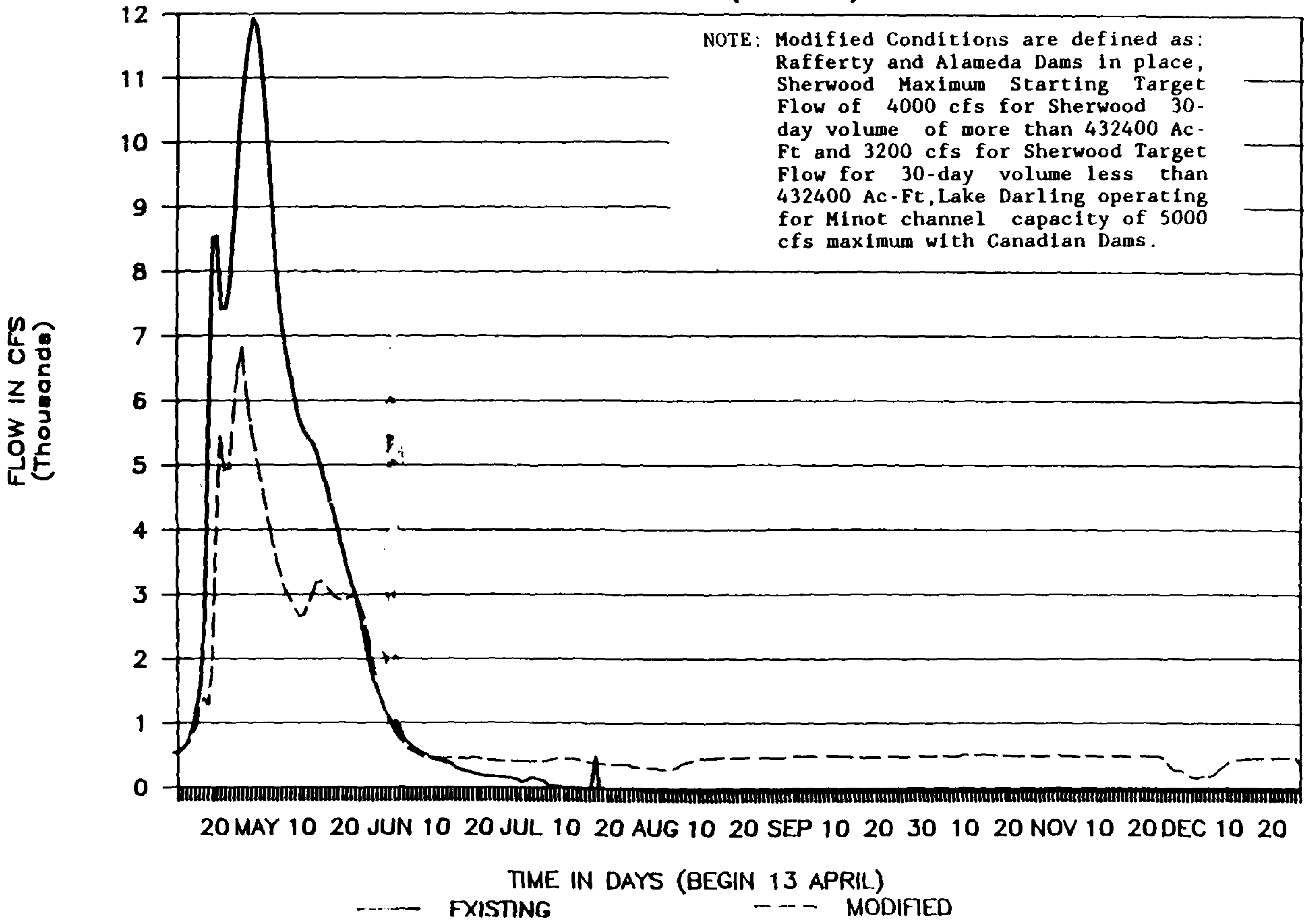
SOURIS RIVER AT WESTHOPE

FLOOD OF 1982



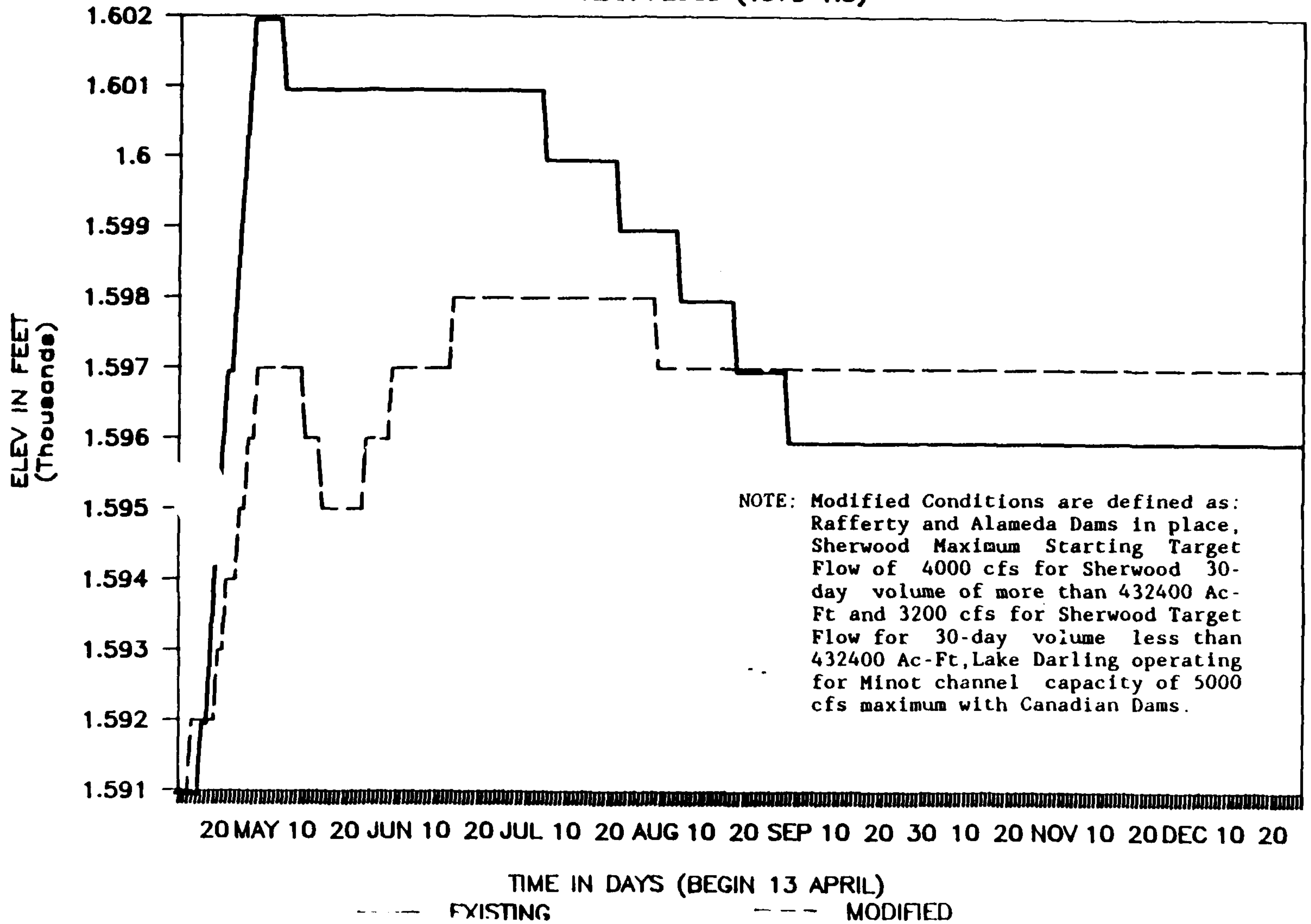
SOURIS RIVER AT SHERWOOD

50 YEAR EVENT (1979*1.5)



ELEVATIONS AT LAKE DARLING

50 YEAR FLOOD (1979*1.5)



NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.

SOURIS RIVER AT FOXHOLM

50 YEAR EVENT (1979*1.5)

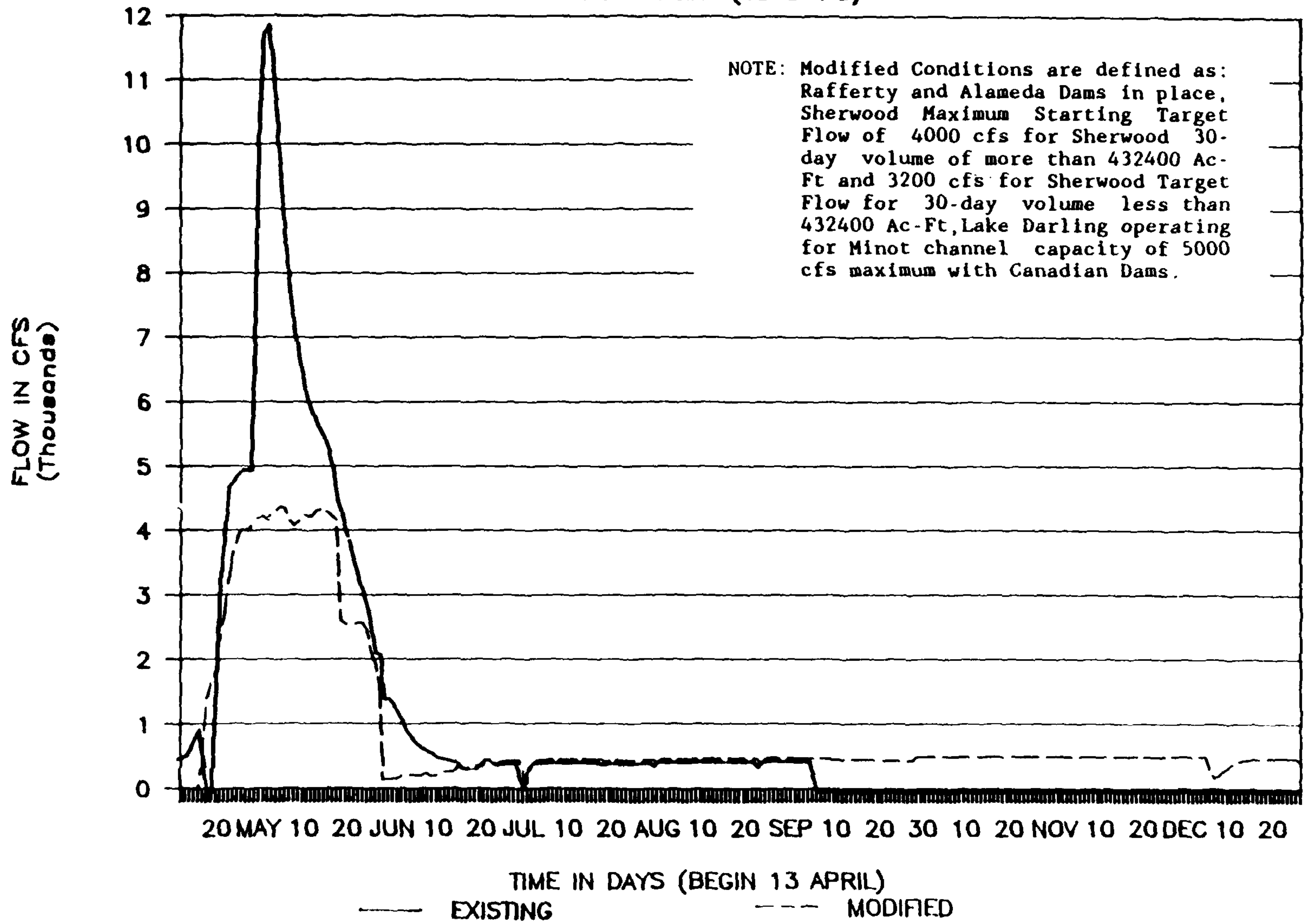
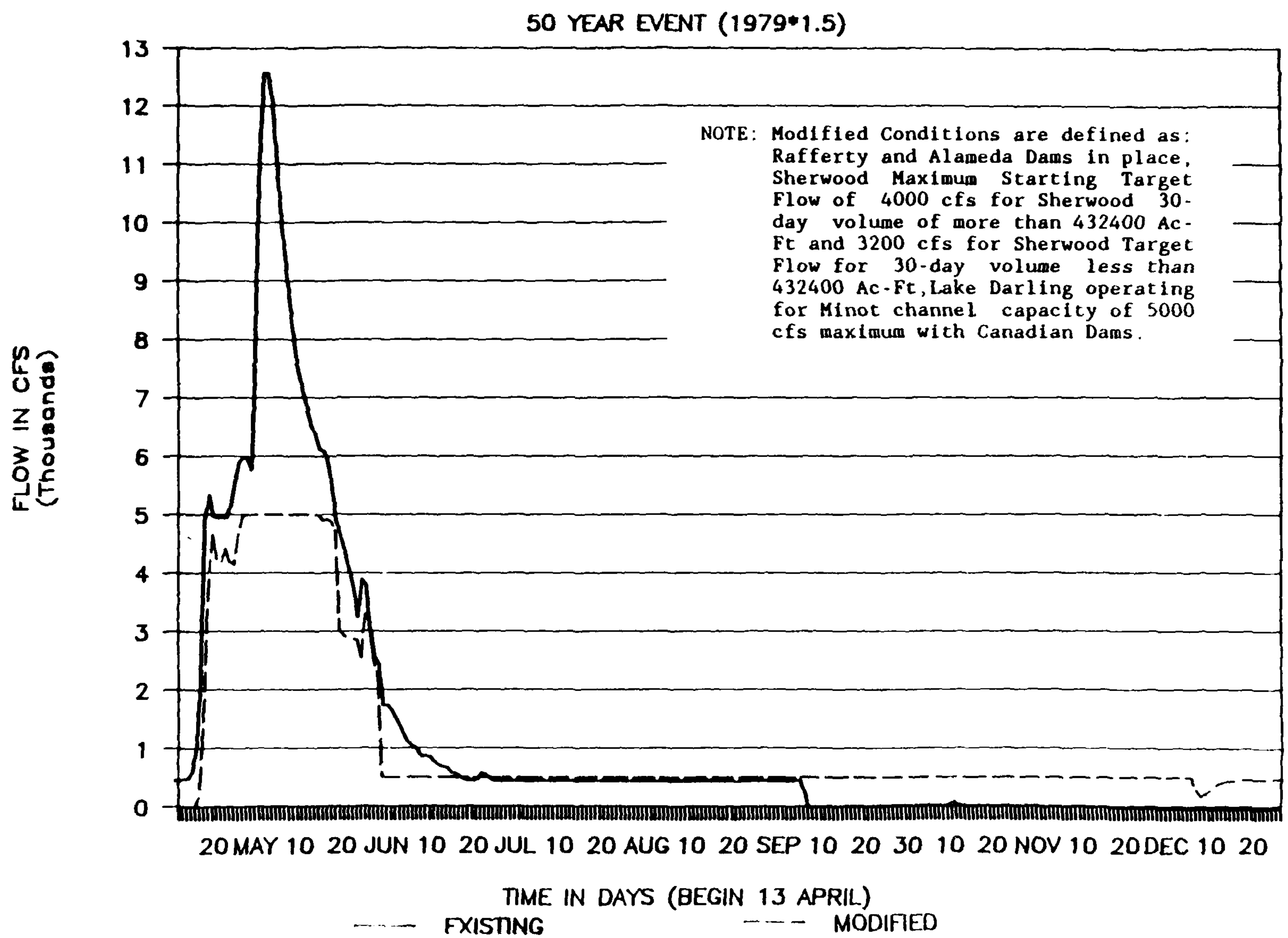


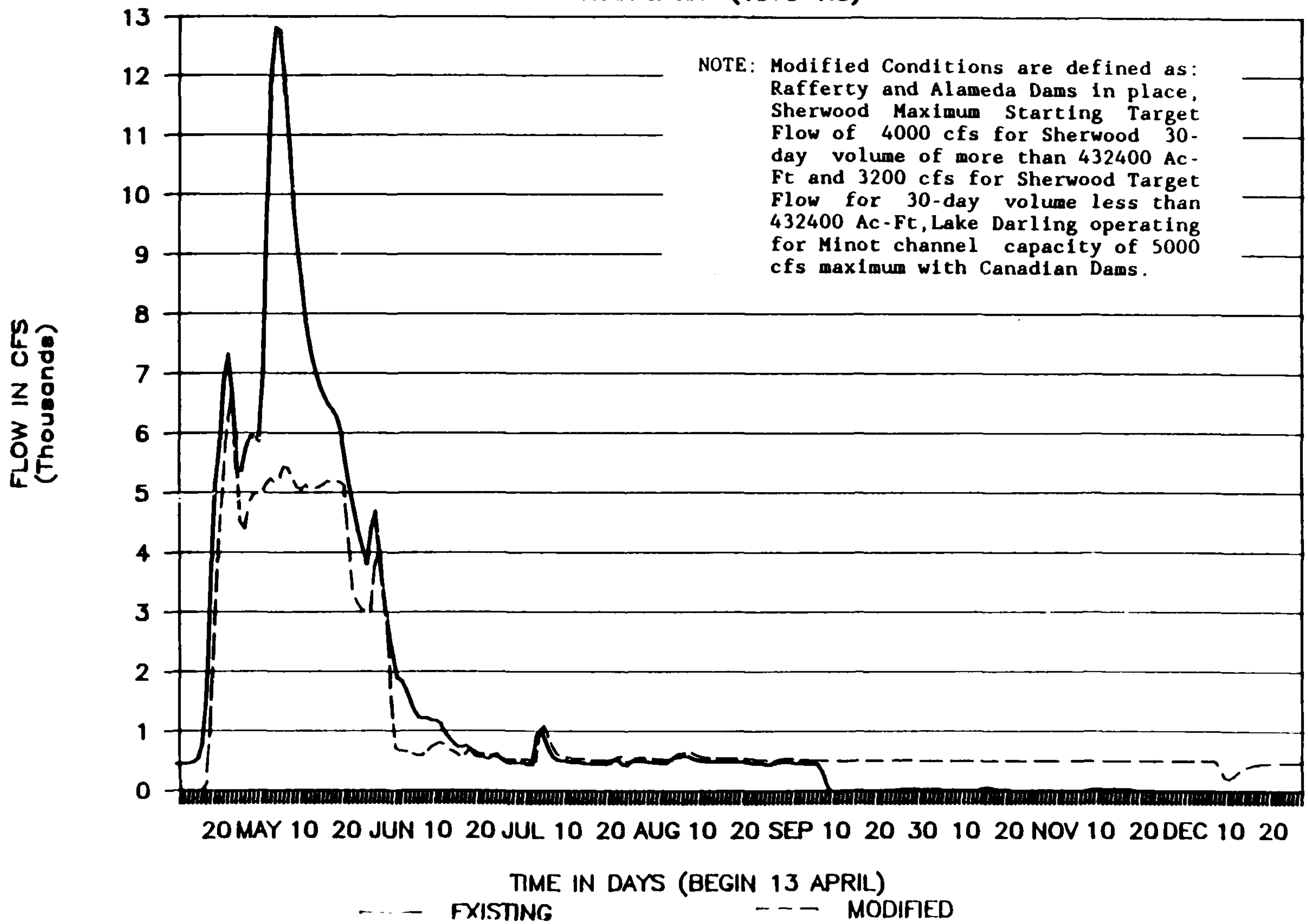
PLATE D-45

SOURIS RIVER AT MINOT



SOURIS RIVER AT VERENDRYE

50 YEAR EVENT (1979*1.5)



NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.

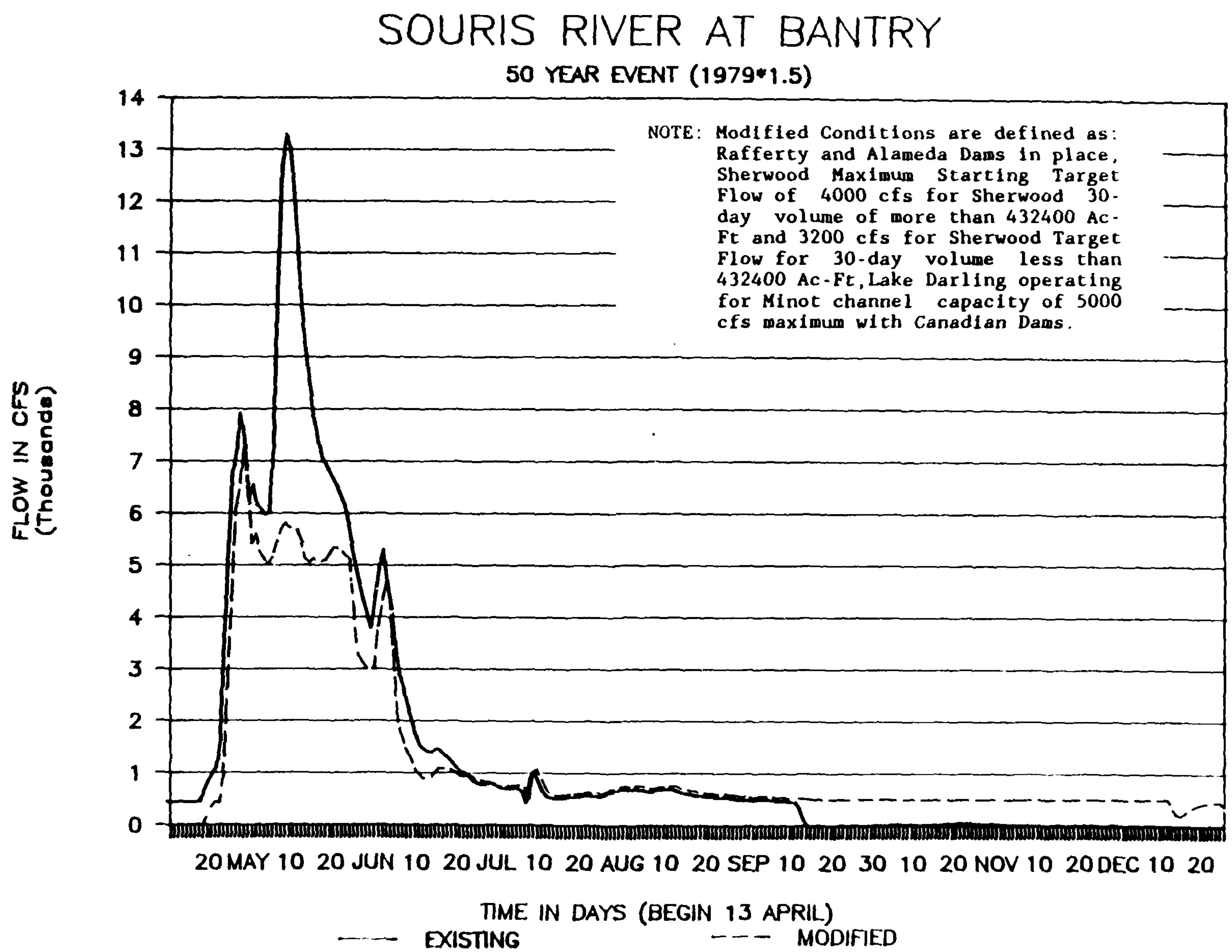
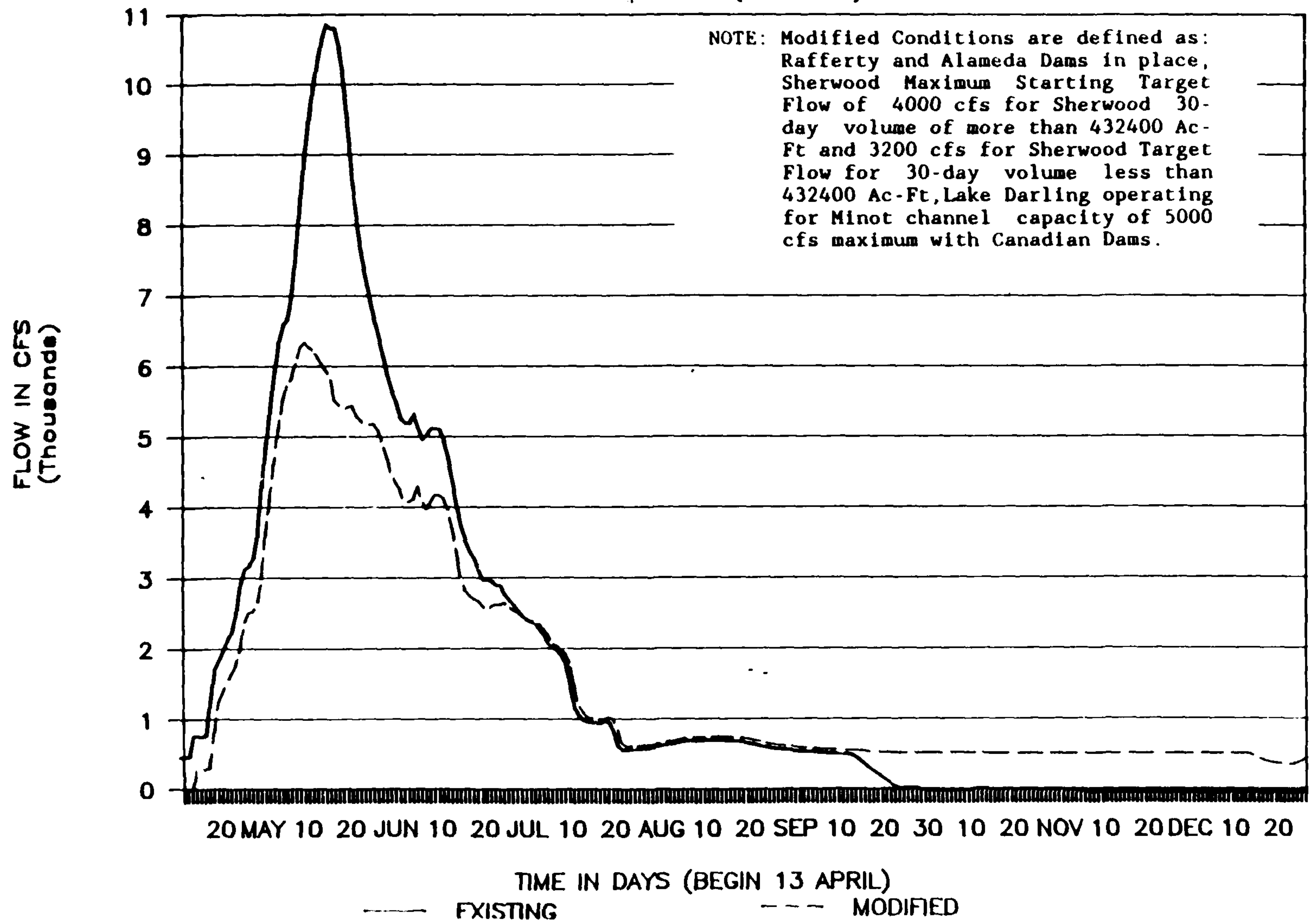

SOURIS RIVER AT BANTRY
50 YEAR EVENT (1979*1.5)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
20 MAY 10 20 JUN 10 20 JUL 10 20 AUG 10 20 SEP 10 20 30 10 20 NOV 10 20 DEC 10 20
TIME IN DAYS (BEGIN 13 APRIL)
EXISTING
MODIFIED

PLATE D-48

SOURIS RIVER AT WESTHOPE

50 YEAR EVENT (1979*1.5)



SOURIS RIVER AT SHERWOOD

70 YEAR EVENT (1976*1.3)

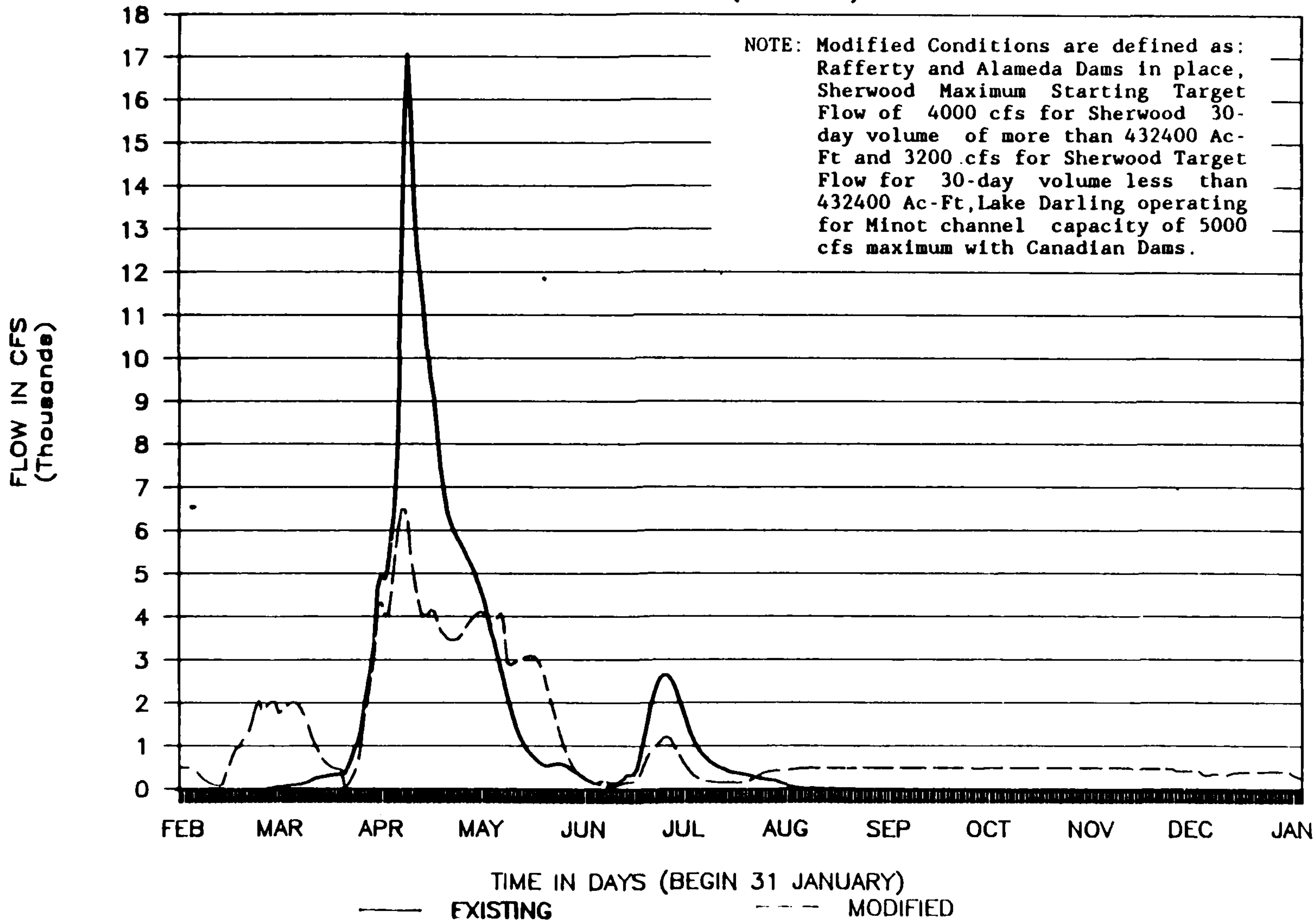


PLATE D-50

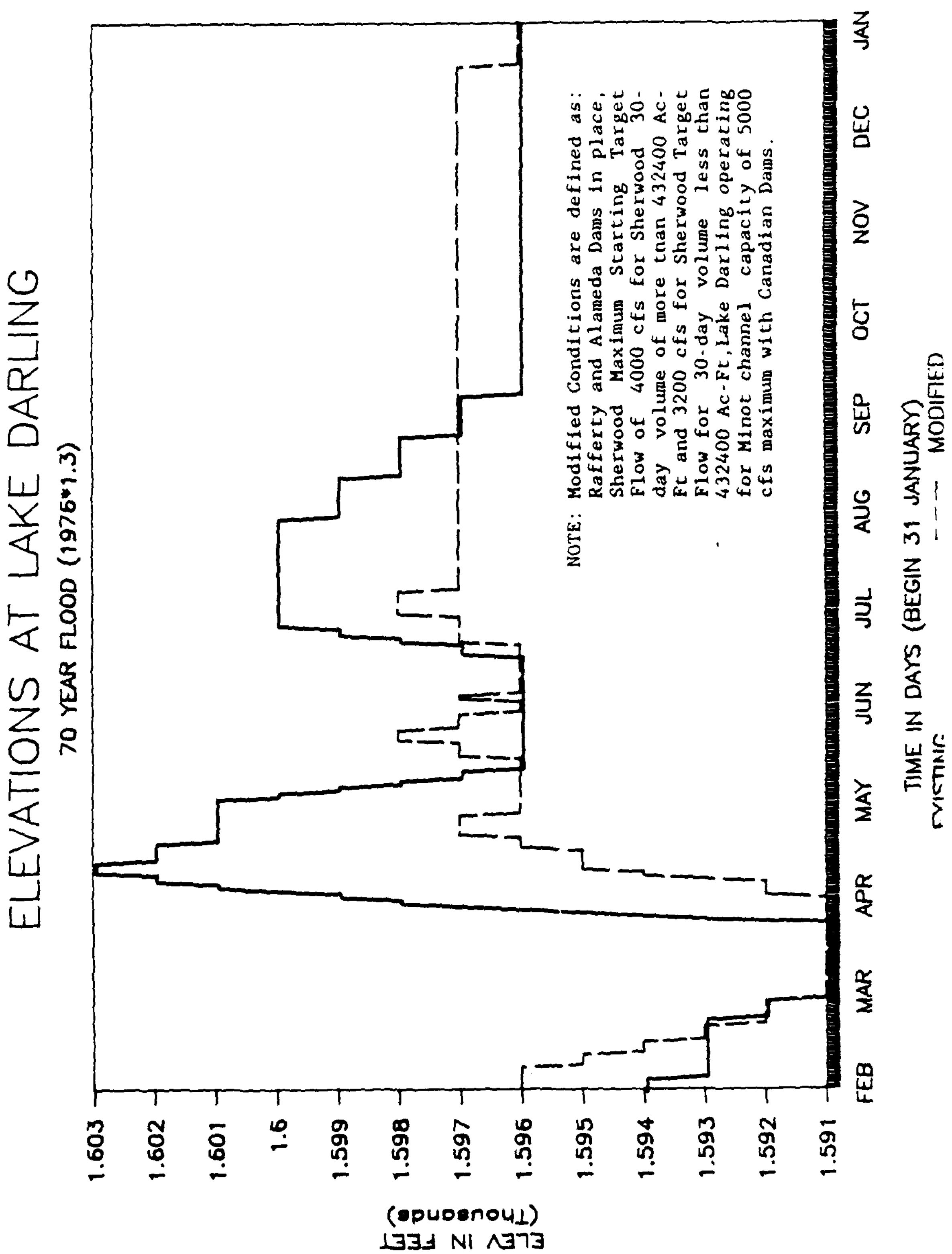
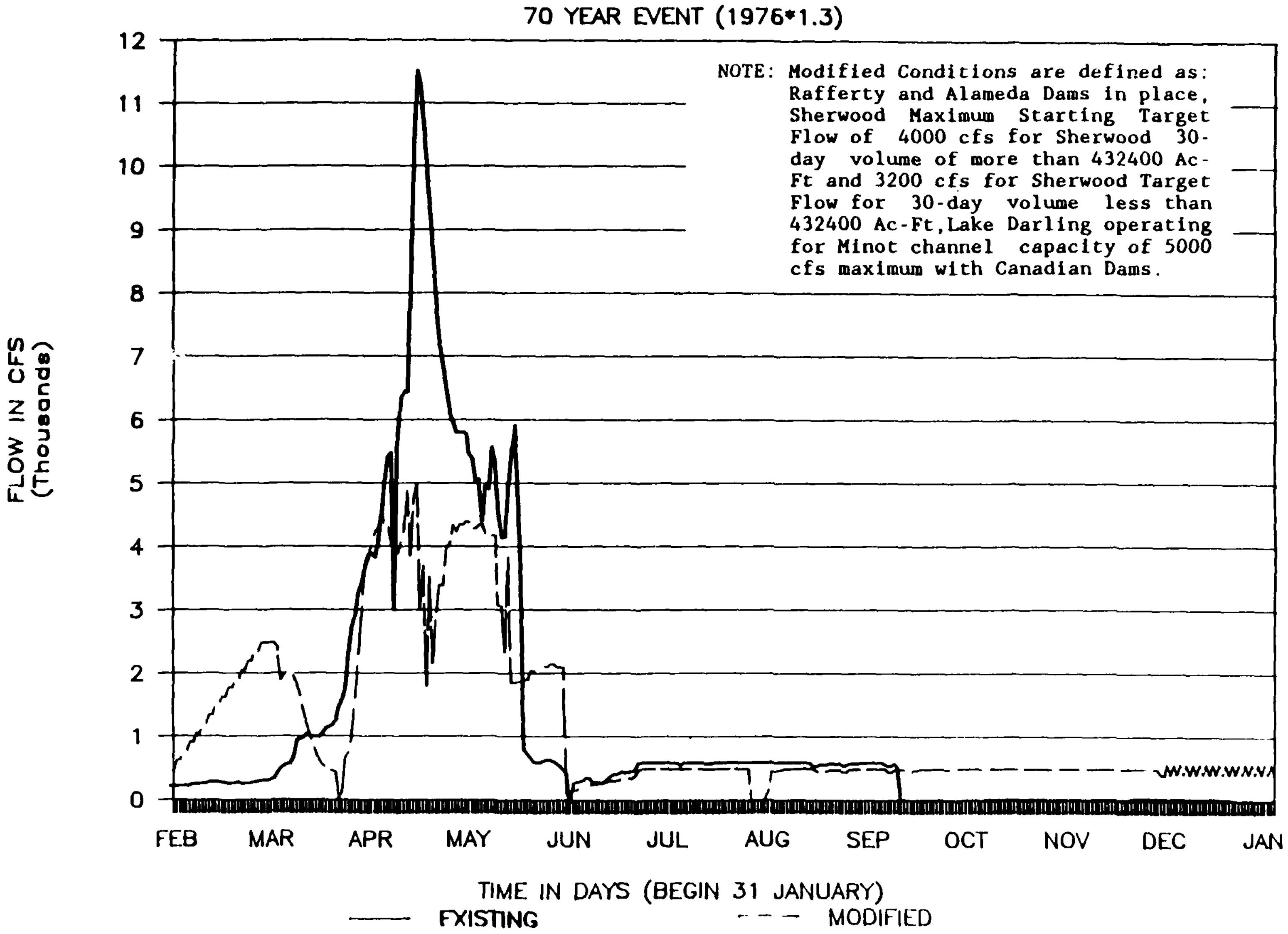

ELEVATIONS AT LAKE DARLING
70 YEAR FLOOD (1976*1.3)
ELEV IN FEET
(Thousands)
1.603
1.602
1.601
1.6
1.599
1.598
1.597
1.596
1.595
1.594
1.593
1.592
1.591
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
TIME IN DAYS (BEGIN 31 JANUARY)
EXISTING
MODIFIED
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more tnan 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.

PLATE D-51

SOURIS RIVER AT FOXHOLM



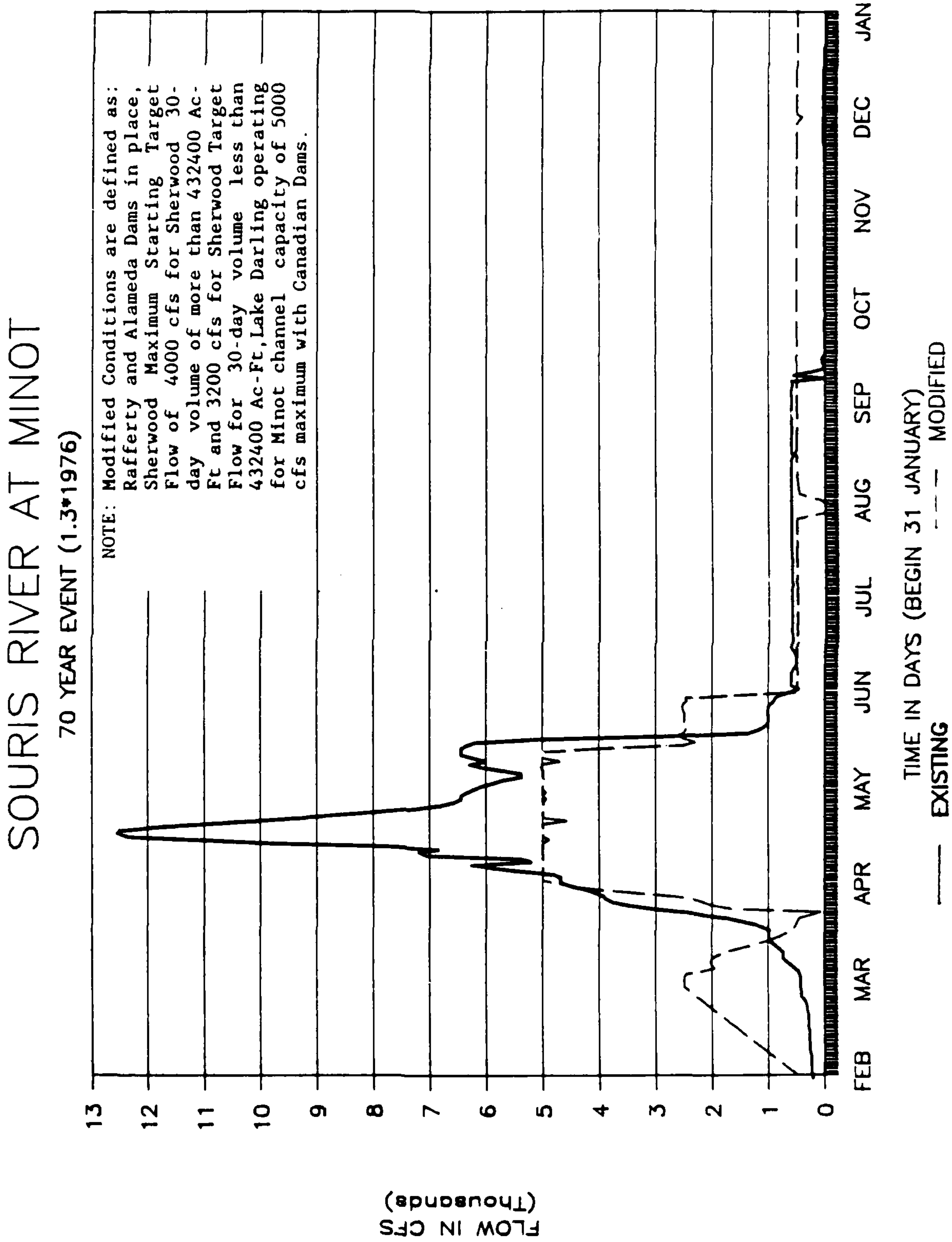
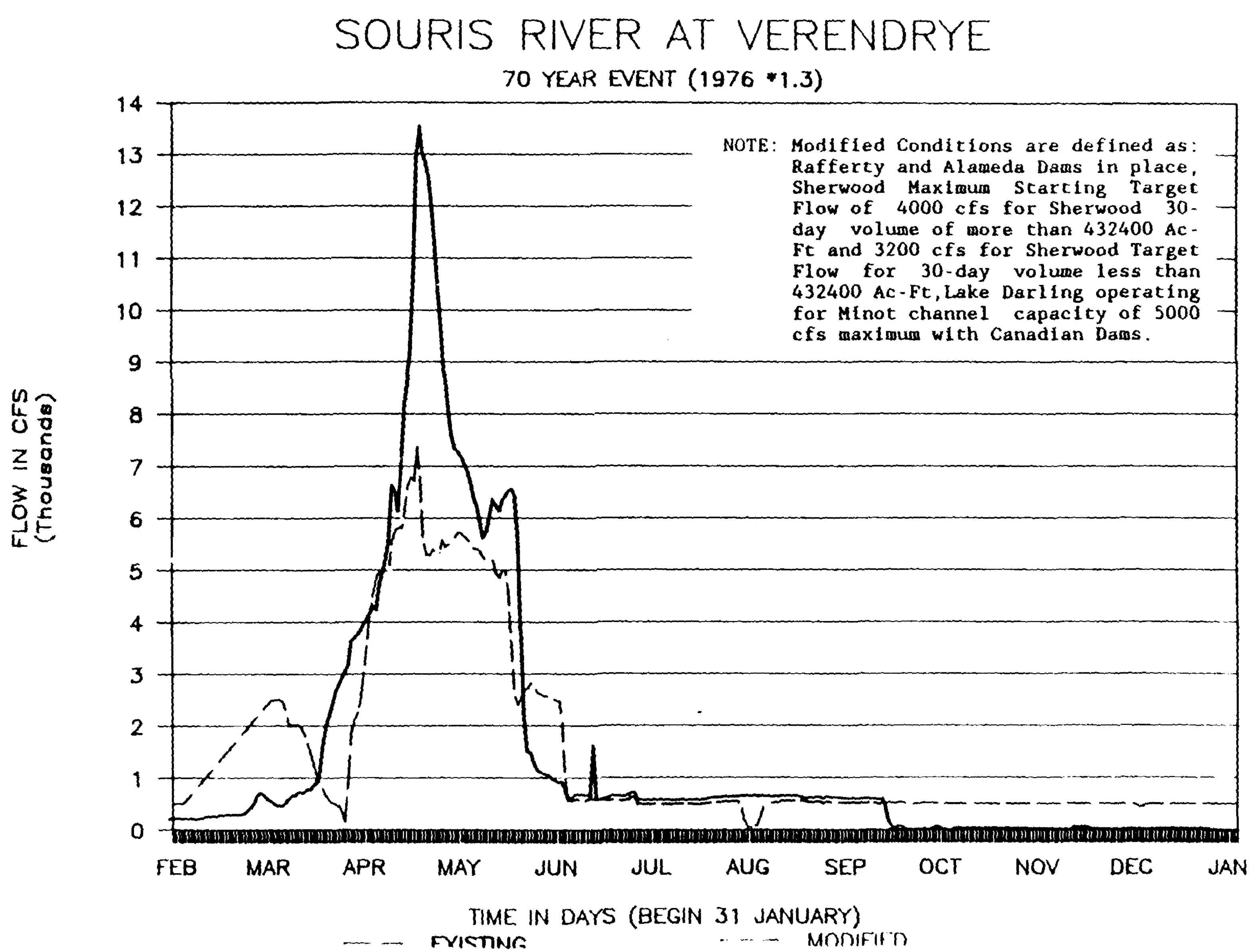

SOURIS RIVER AT MINOT
70 YEAR EVENT (1.3*1976)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS
(Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
TIME IN DAYS (BEGIN 31 JANUARY)
EXISTING
MODIFIED

PLATE D-53



SOURIS RIVER AT VERENDRYE
70 YEAR EVENT (1976 *1.3)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS
(Thousands)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
TIME IN DAYS (BEGIN 31 JANUARY)
EXISTING
MODIFIED

PLATE D-54

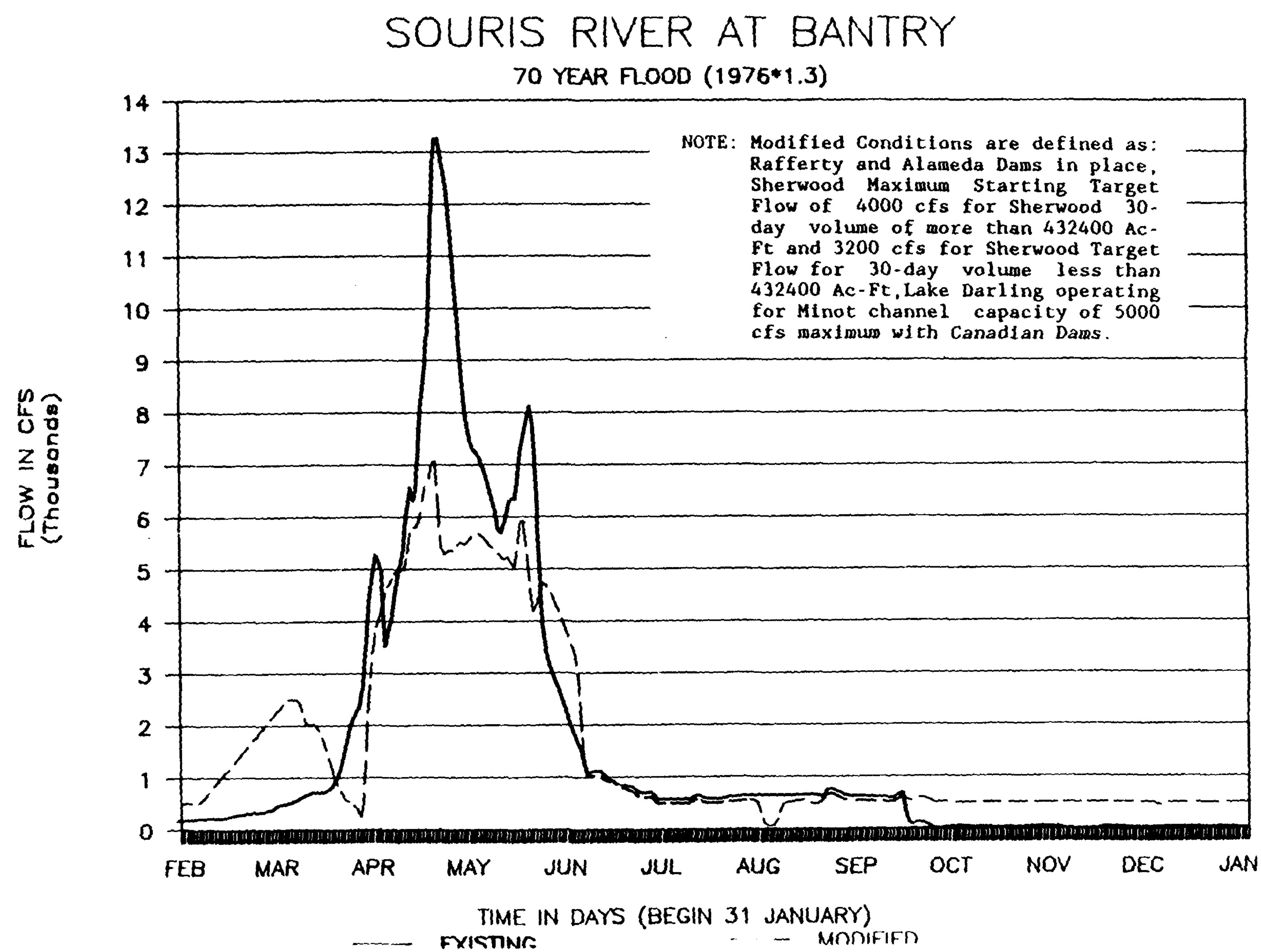
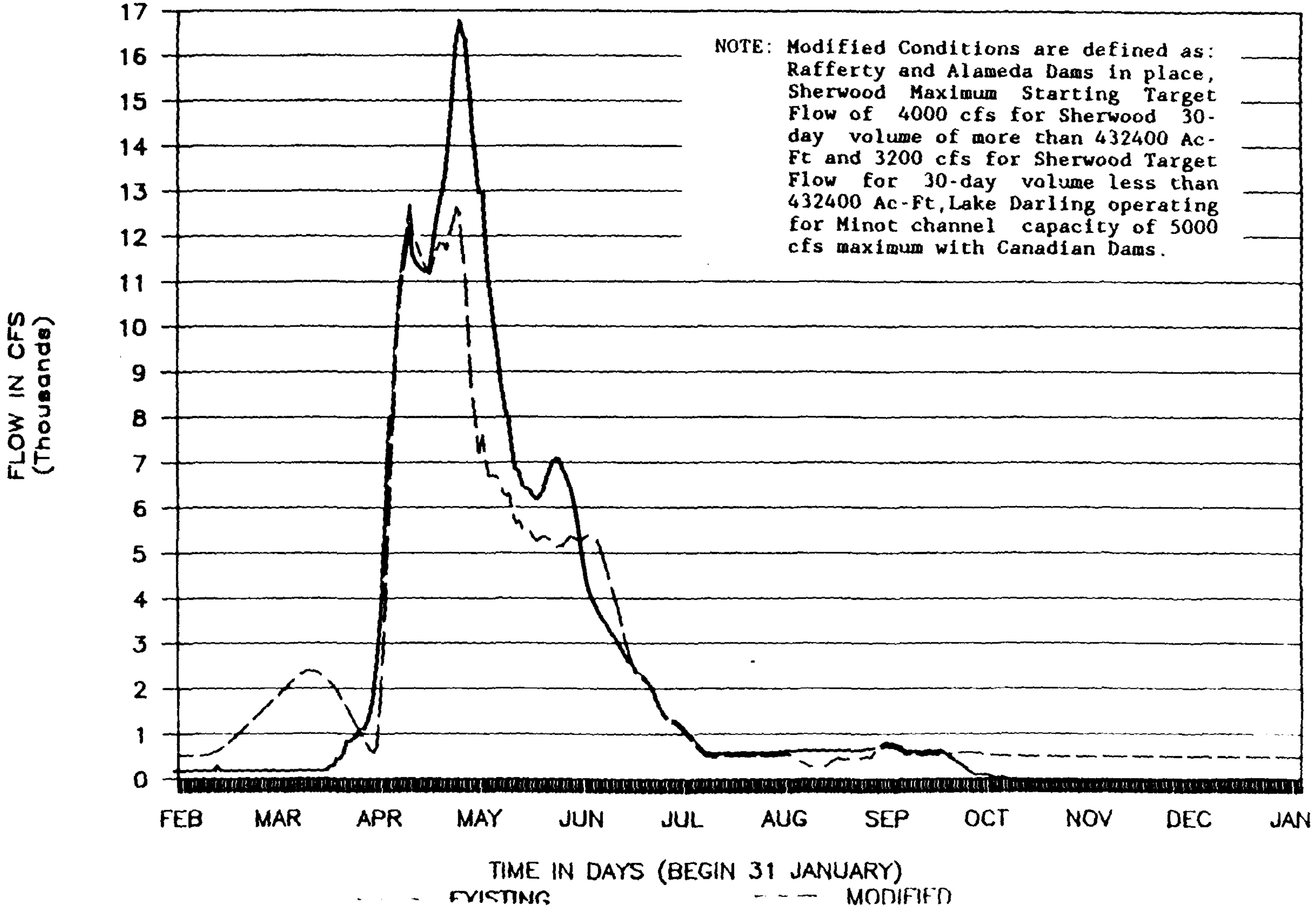
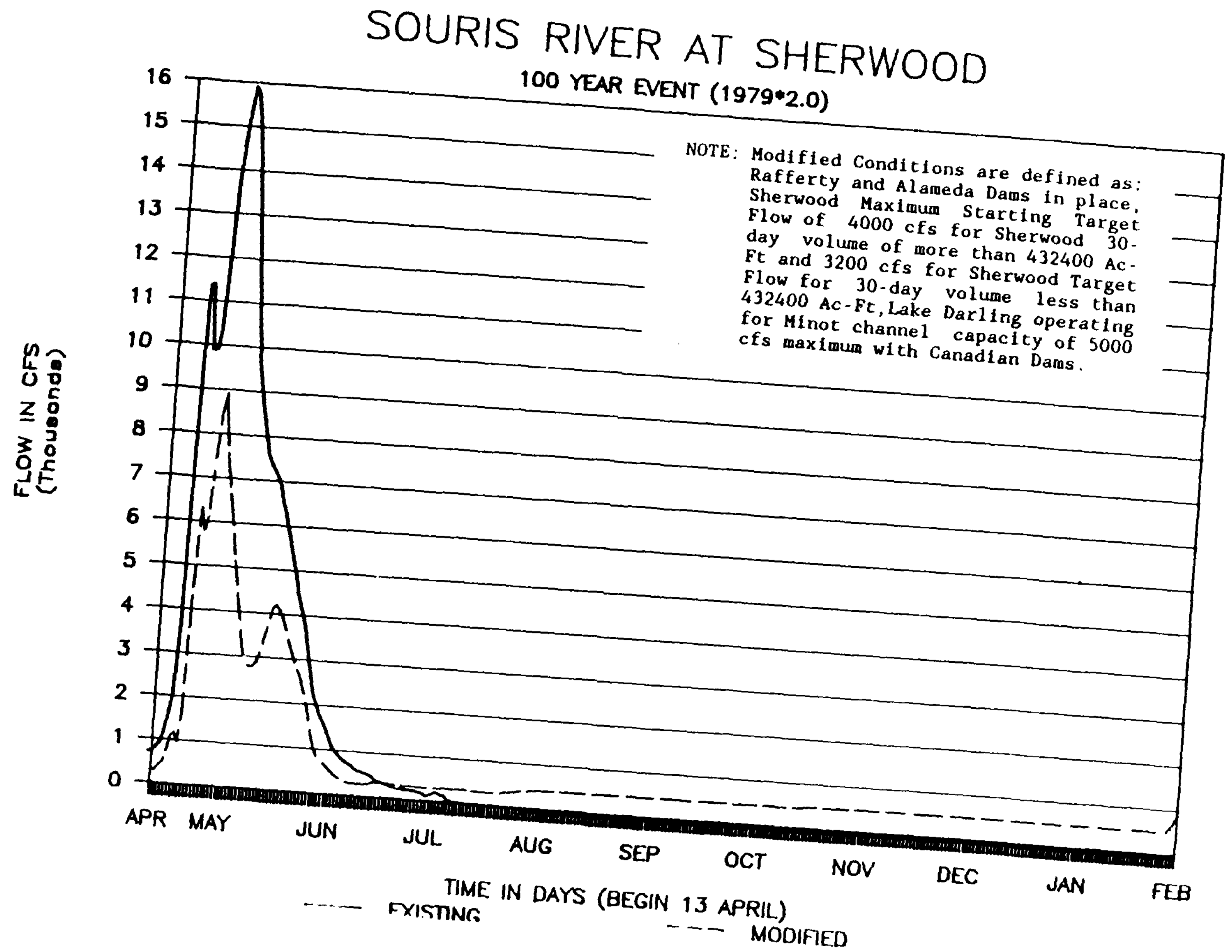

SOURIS RIVER AT BANTRY
70 YEAR FLOOD (1976*1.3)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
TIME IN DAYS (BEGIN 31 JANUARY)
EXISTING
MODIFIED

PLATE D-55

SOURIS RIVER AT WESTHOPE

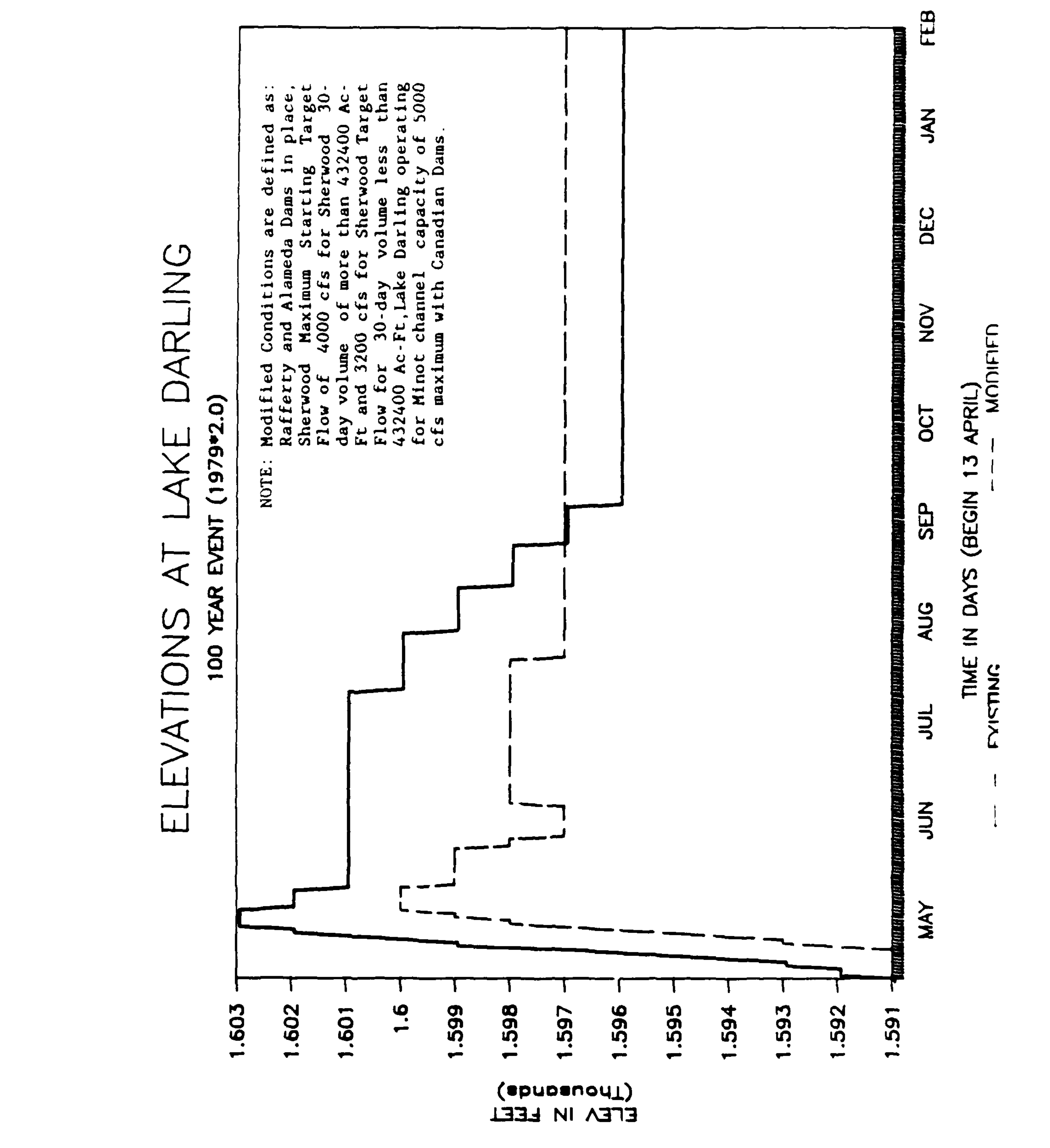
70 YEAR EVENT (1976*1.3)





SOURIS RIVER AT SHERWOOD
100 YEAR EVENT (1979*2.0)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
TIME IN DAYS (BEGIN 13 APRIL)
EXISTING
MODIFIED

PLATE D-57



ELEVATIONS AT LAKE DARLING
100 YEAR EVENT (1979*2.0)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
ELEV IN FEET
(Thousands)
1.603
1.602
1.601
1.6
1.599
1.598
1.597
1.596
1.595
1.594
1.593
1.592
1.591
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
TIME IN DAYS (BEGIN 13 APRIL)
EXISTING
MODIFIED

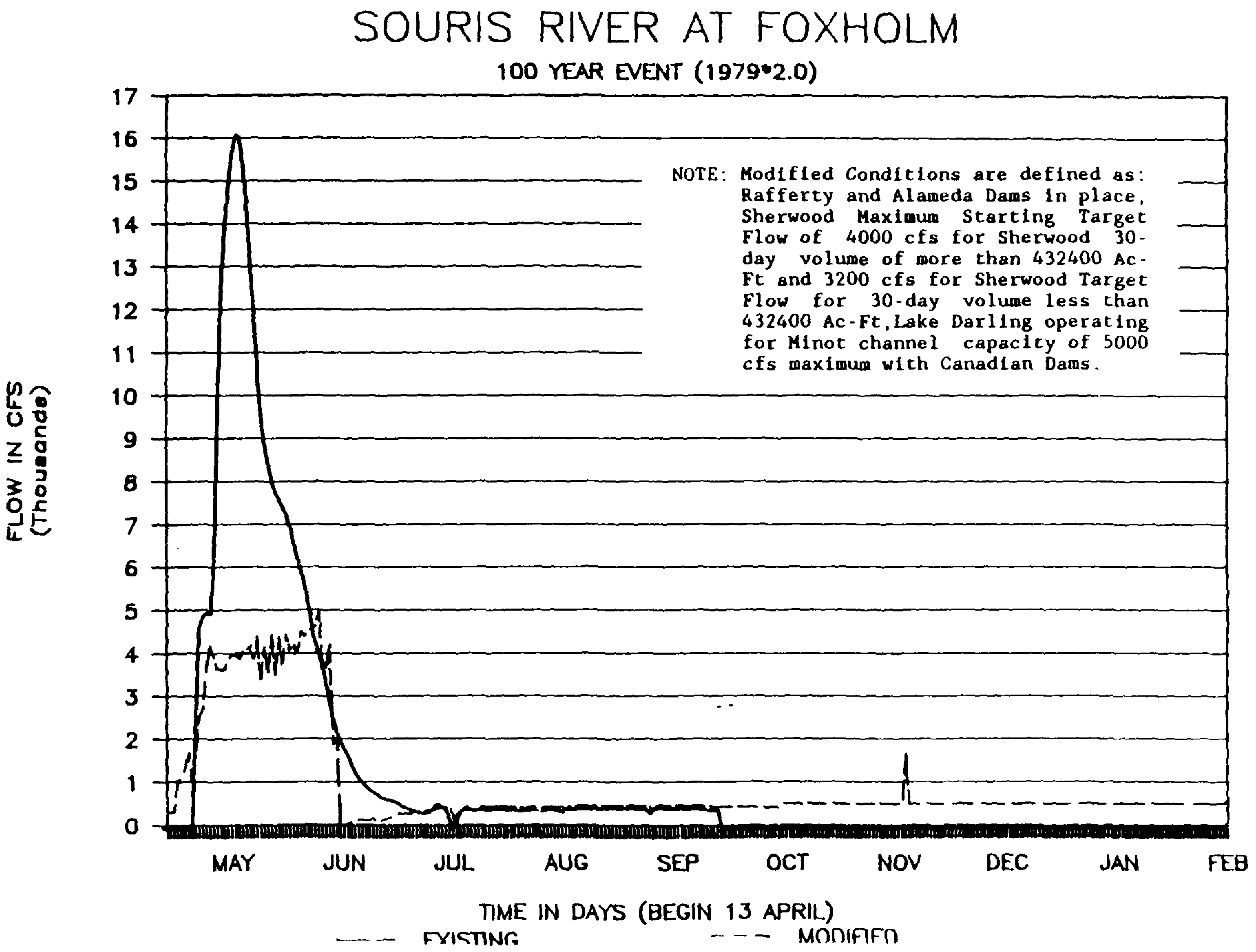

SOURIS RIVER AT FOXHOLM
100 YEAR EVENT (1979*2.0)
FLOW IN CFS (Thousands)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
TIME IN DAYS (BEGIN 13 APRIL)
EXISTING
MODIFIED

PLATE D-59

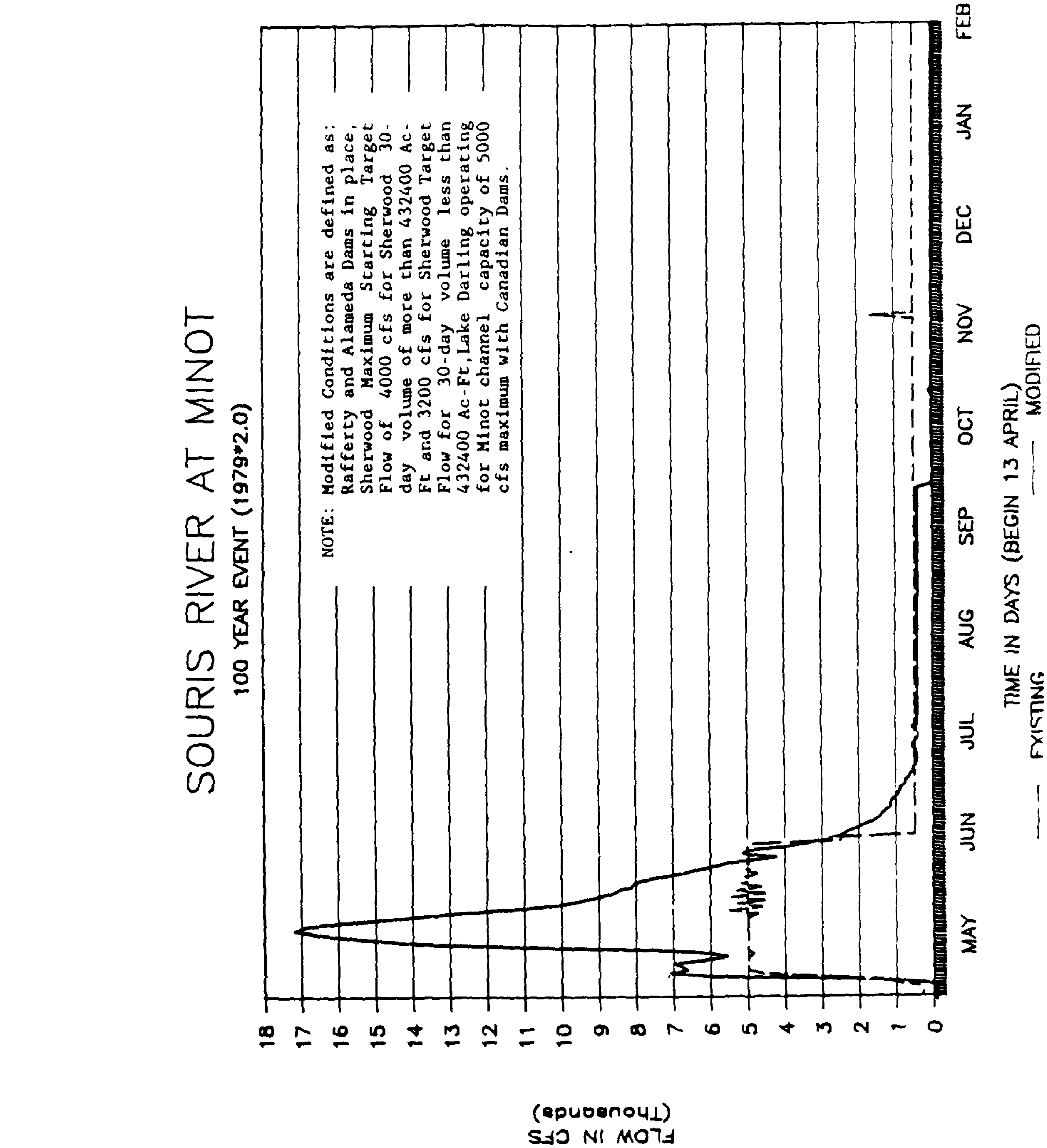
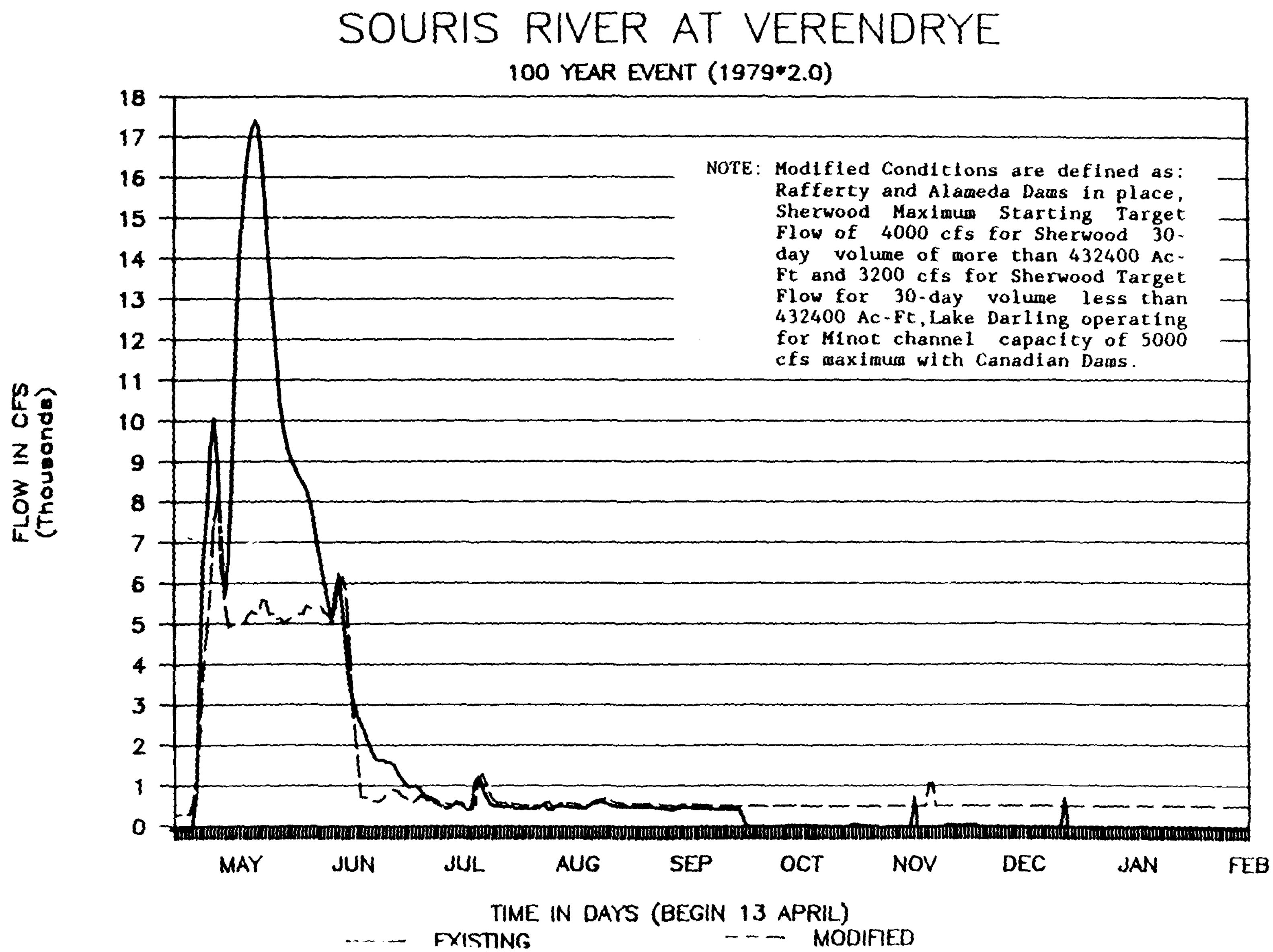
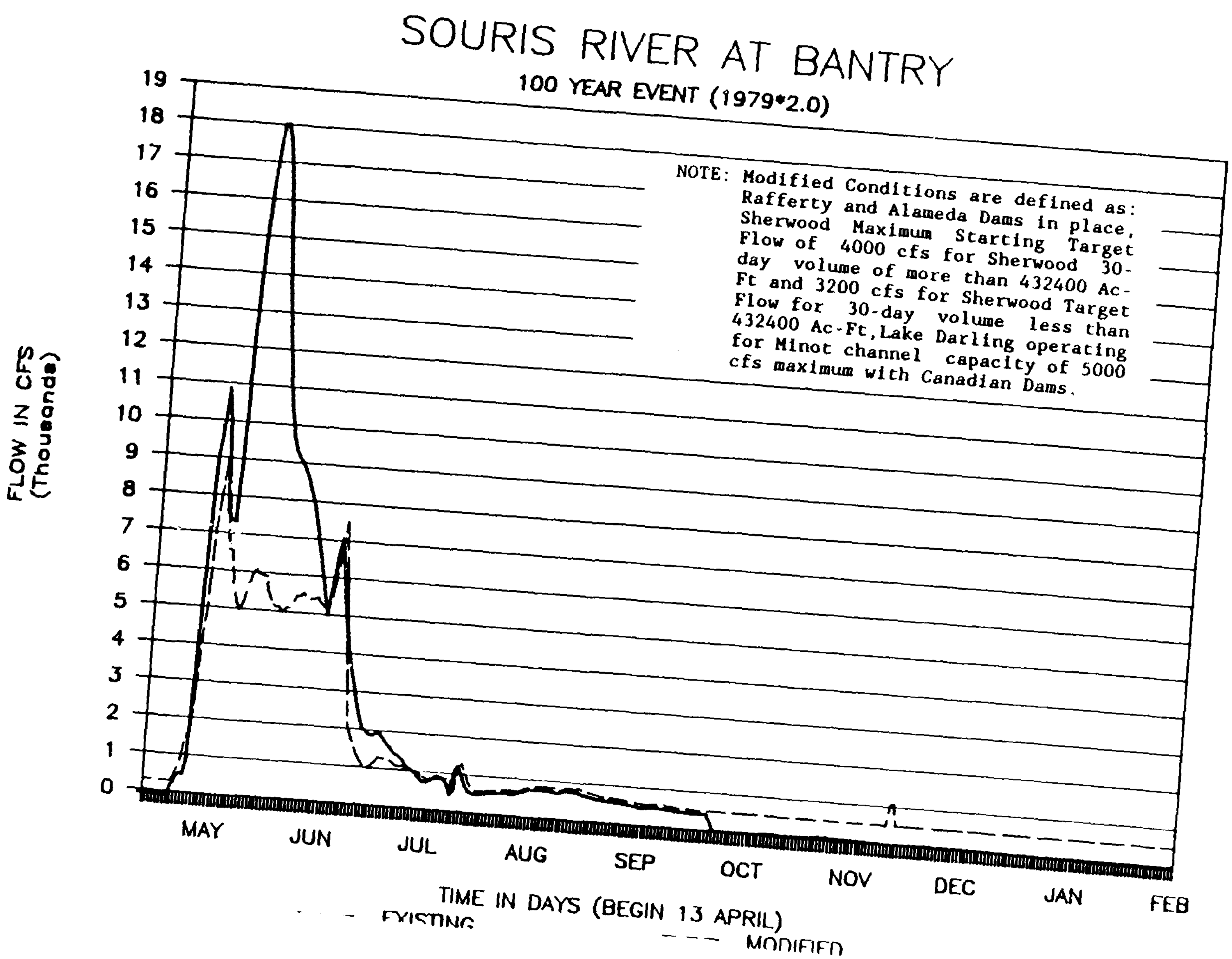

SOURIS RIVER AT MINOT
100 YEAR EVENT (1979*2.0)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB
TIME IN DAYS (BEGIN 13 APRIL)
EXISTING
MODIFIED

PLATE D-60


SOURIS RIVER AT VERENDRYE
100 YEAR EVENT (1979*2.0)
FLOW IN CFS (Thousands)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
TIME IN DAYS (BEGIN 13 APRIL)
EXISTING
MODIFIED
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.


SOURIS RIVER AT BANTRY
100 YEAR EVENT (1979*2.0)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS
(Thousands)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
TIME IN DAYS (BEGIN 13 APRIL)
EXISTING
MODIFIED

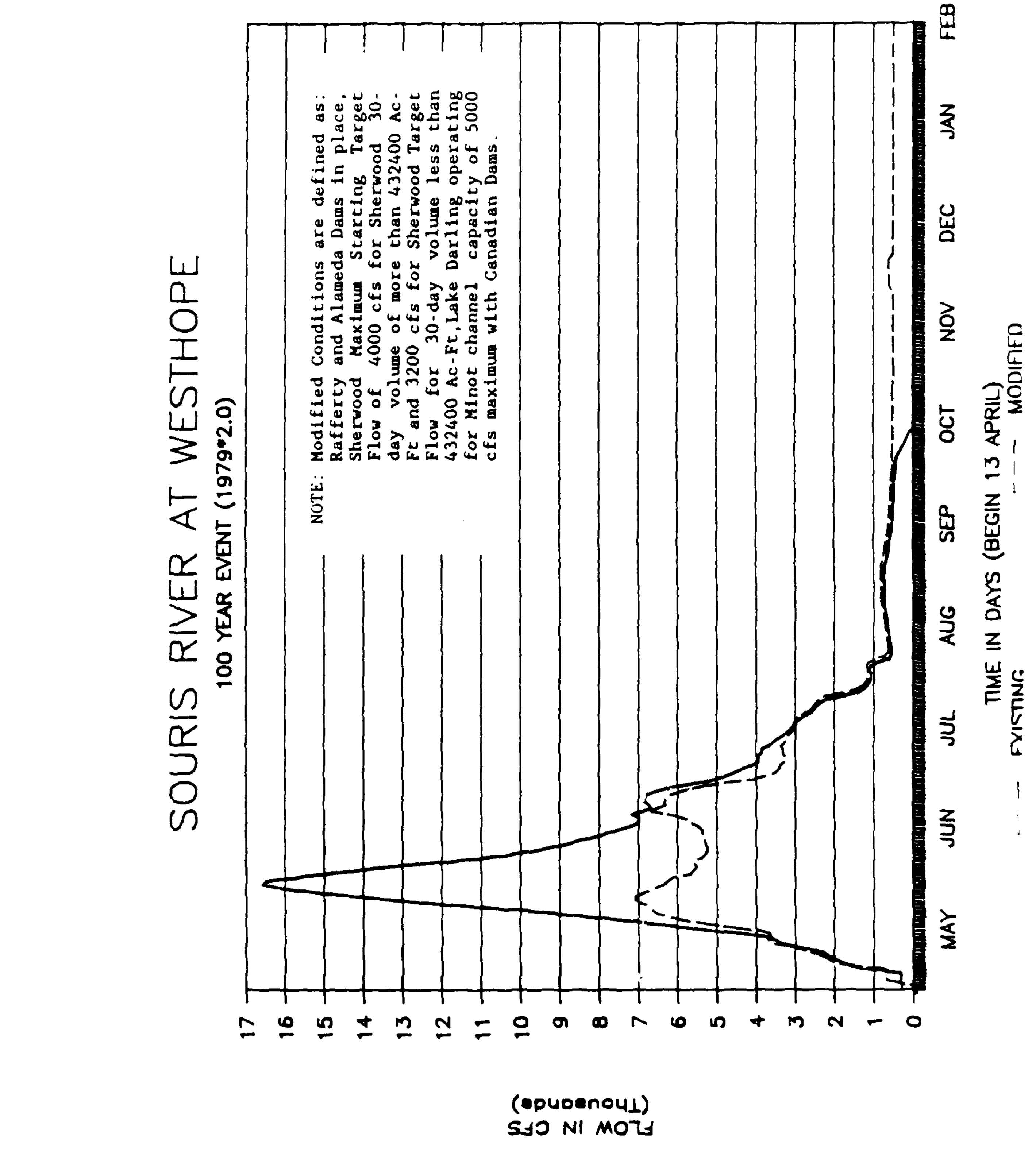

SOURIS RIVER AT WESTHOPE
100 YEAR EVENT (1979*2.0)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS
(Thousands)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
TIME IN DAYS (BEGIN 13 APRIL)
EXISTING
MODIFIED

PLATE D-63

SOURIS RIVER AT SHERWOOD

100 YEAR EVENT (1976*1.5)

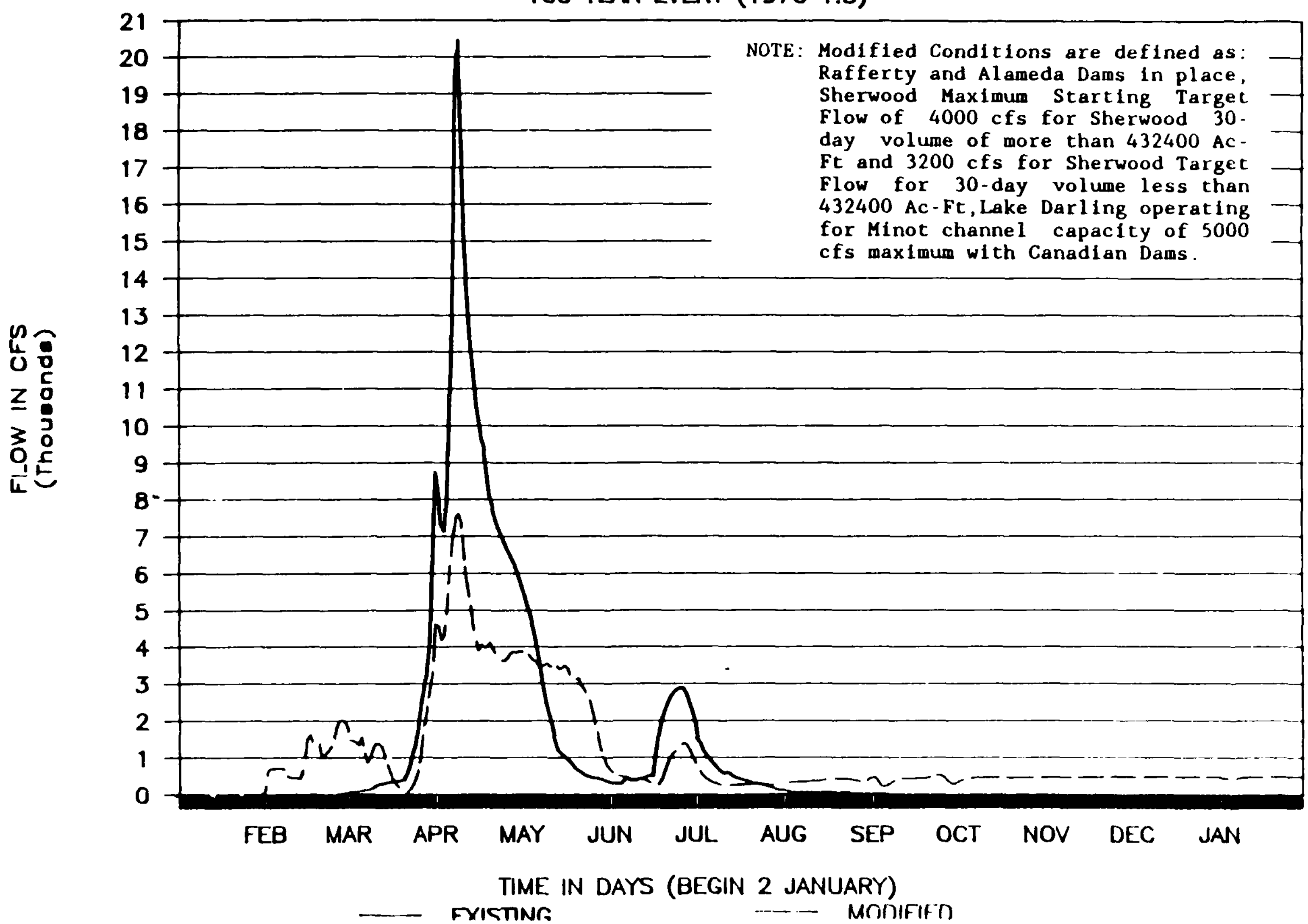


PLATE D-64

ELEVATIONS AT LAKE DARLING

100 YEAR EVENT (1976*1.5)

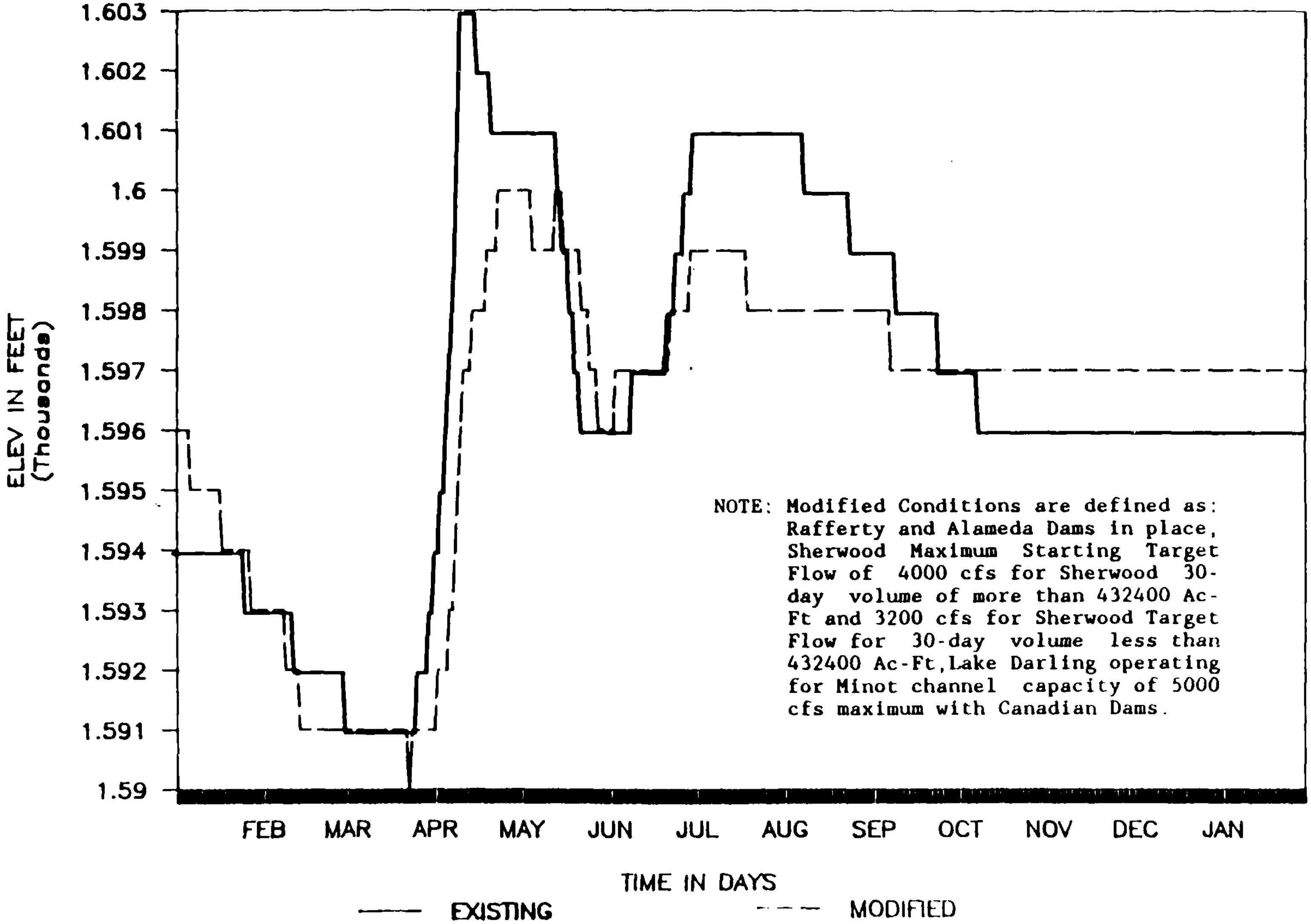
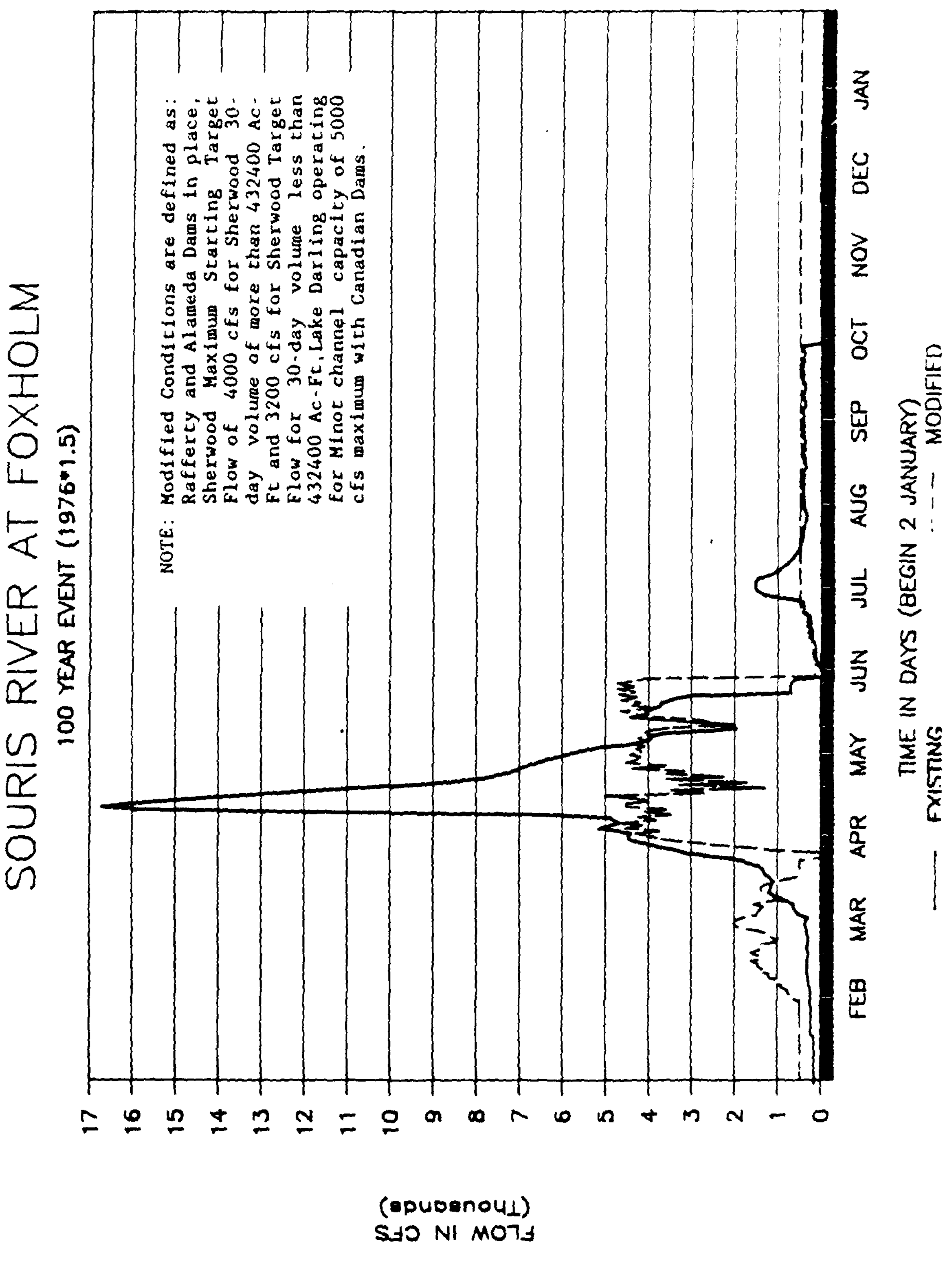
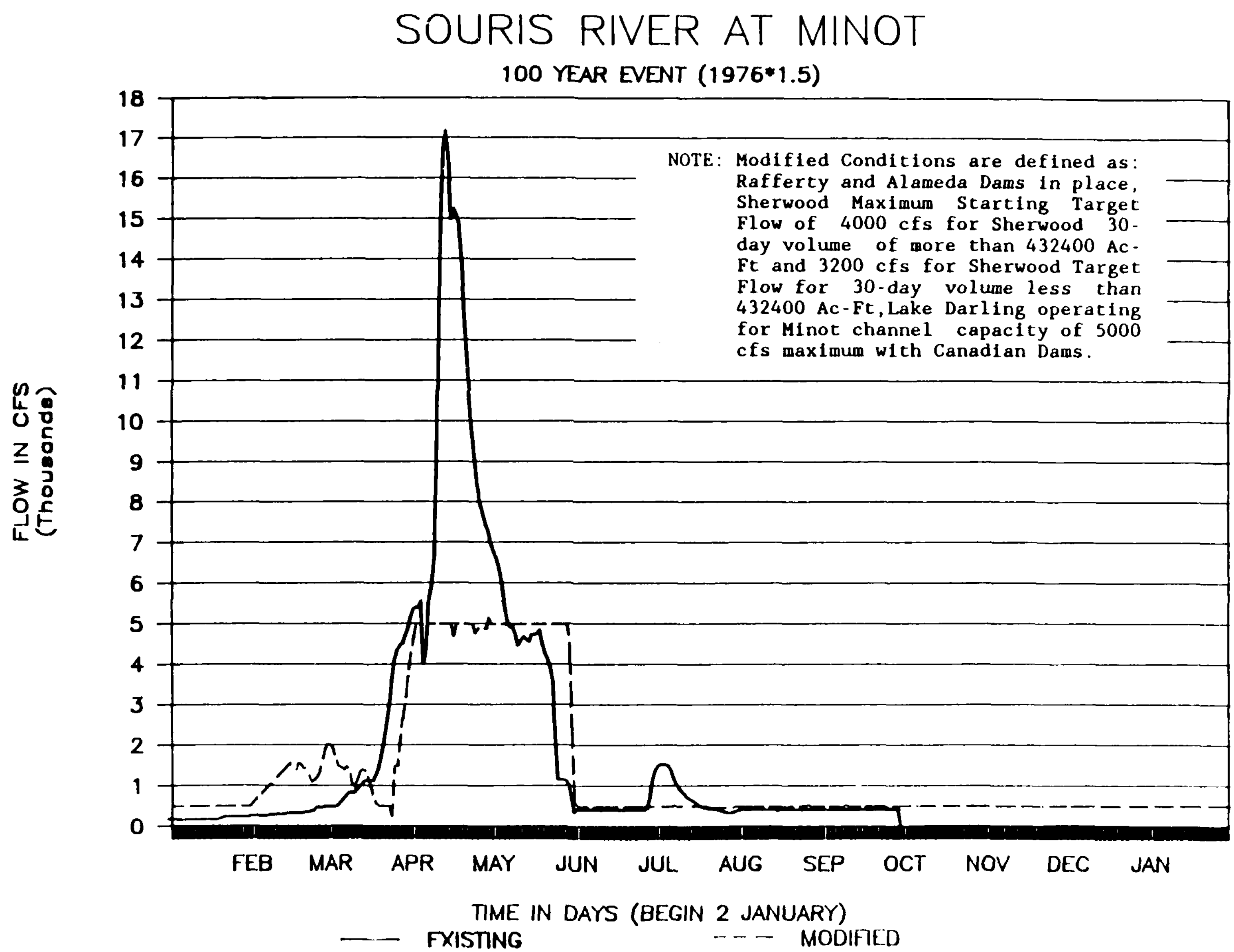


PLATE D-65



SOURIS RIVER AT FOXHOLM
100 YEAR EVENT (1976*1.5)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS (Thousands)
17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN
TIME IN DAYS (BEGIN 2 JANUARY)
EXISTING
MODIFIED

PLATE D-66


SOURIS RIVER AT MINOT
100 YEAR EVENT (1976*1.5)
FLOW IN CFS (Thousands)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
TIME IN DAYS (BEGIN 2 JANUARY)
FXISTING
MODIFIED

SOURIS RIVER AT VERENDRYE

100 YEAR EVENT (1976*1.5)

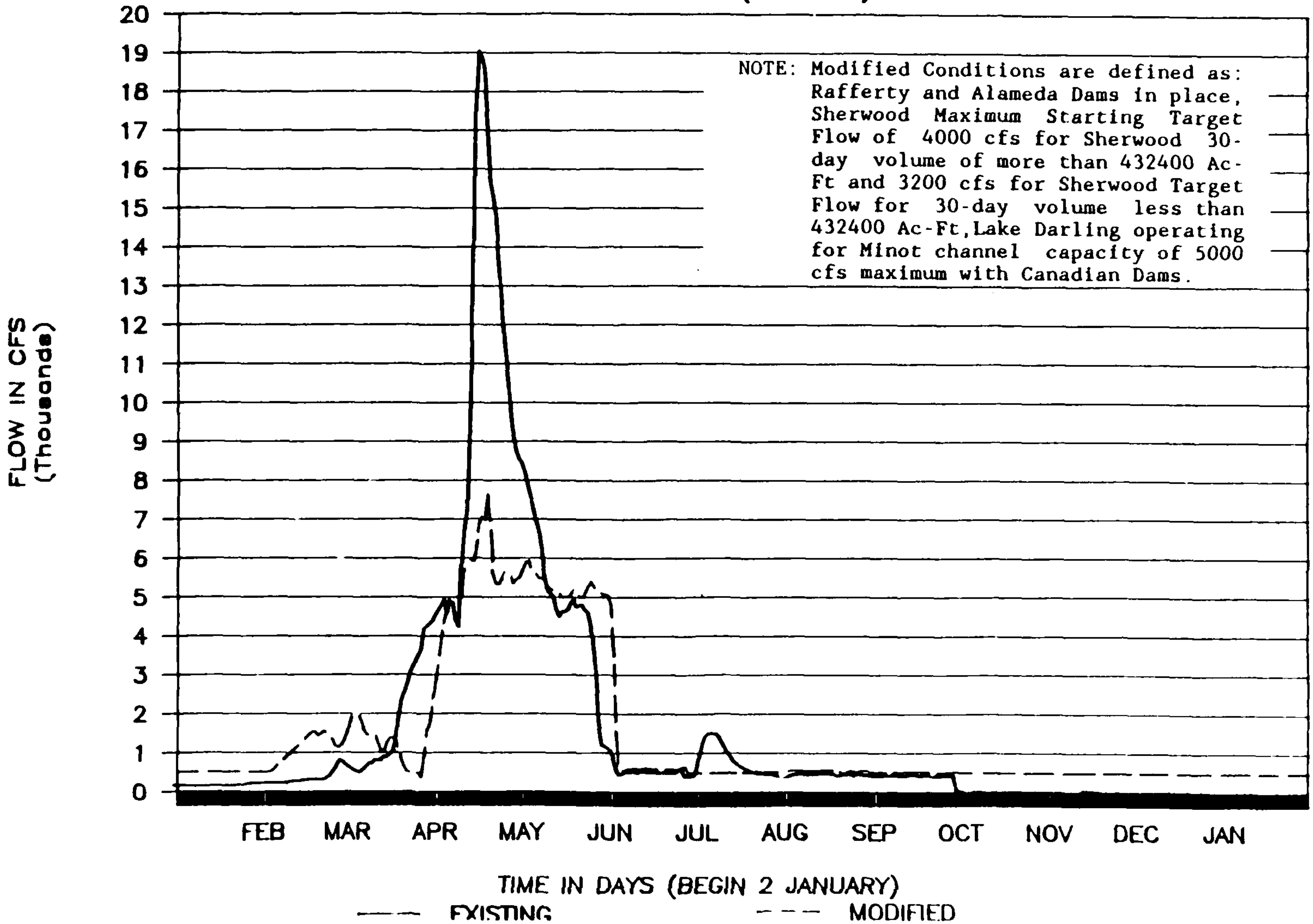
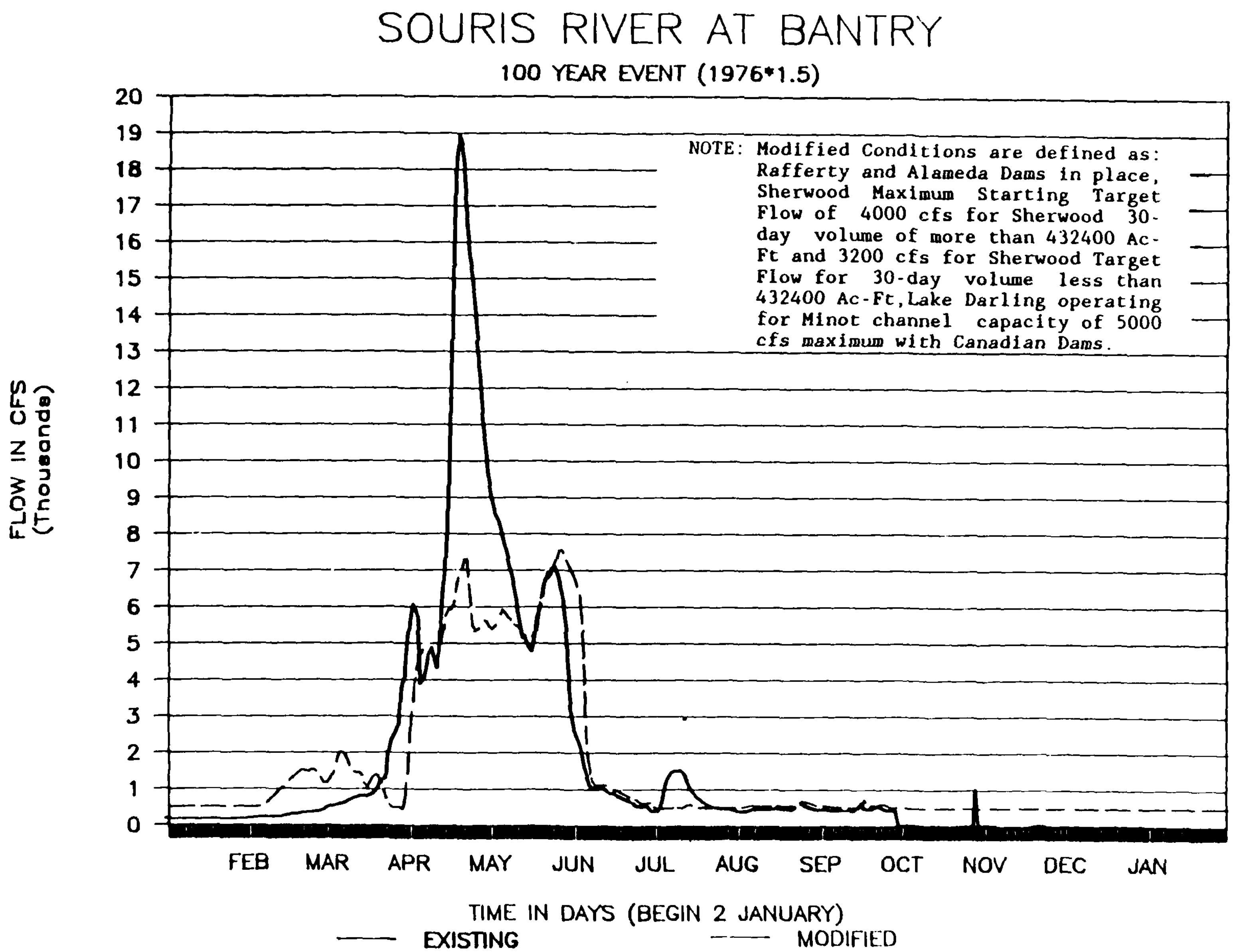
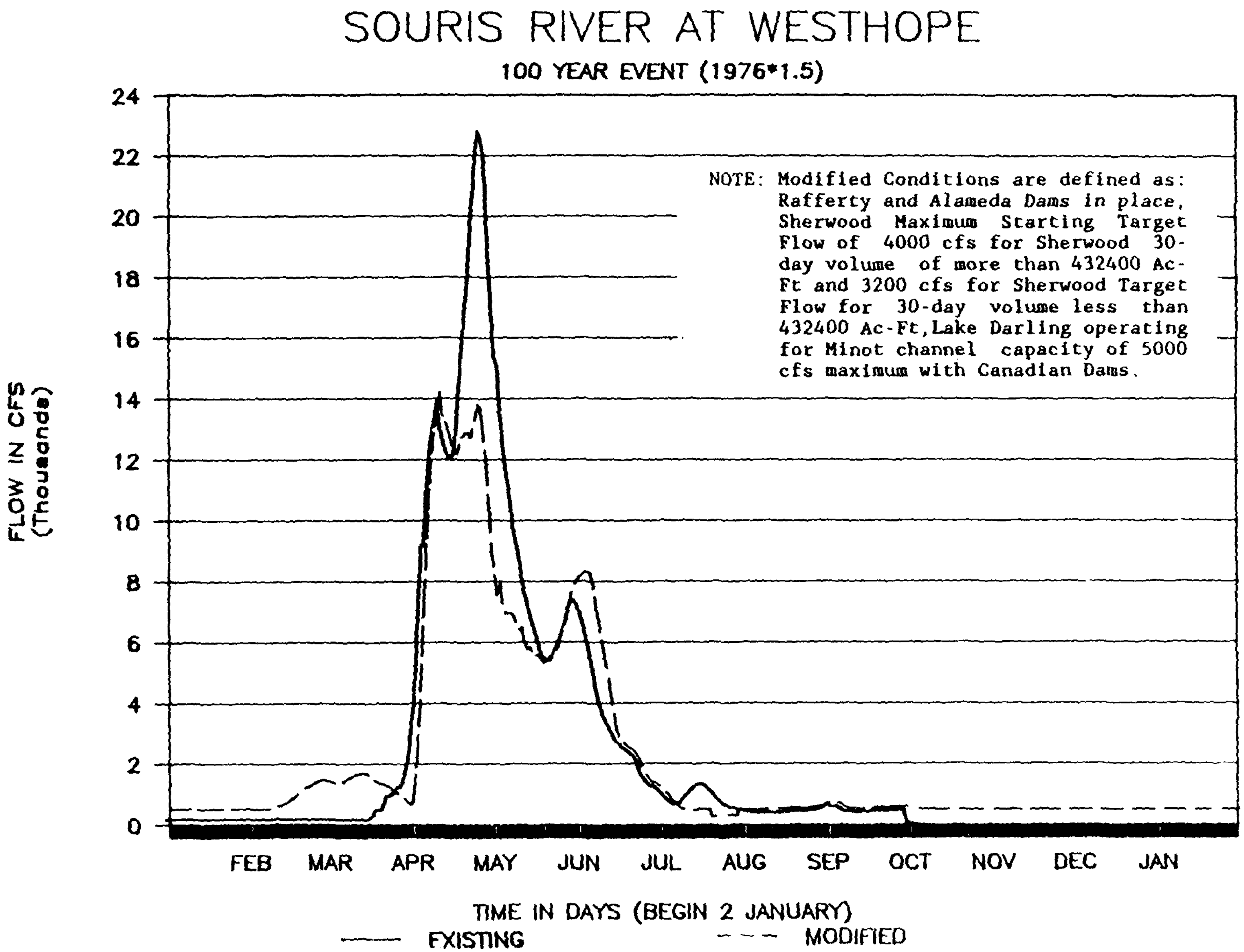


PLATE D-68


SOURIS RIVER AT BANTRY
100 YEAR EVENT (1976*1.5)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS
(Thousands)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
TIME IN DAYS (BEGIN 2 JANUARY)
EXISTING
MODIFIED



SOURIS RIVER AT WESTHOPE
100 YEAR EVENT (1976*1.5)
NOTE: Modified Conditions are defined as: Rafferty and Alameda Dams in place, Sherwood Maximum Starting Target Flow of 4000 cfs for Sherwood 30-day volume of more than 432400 Ac-Ft and 3200 cfs for Sherwood Target Flow for 30-day volume less than 432400 Ac-Ft, Lake Darling operating for Minot channel capacity of 5000 cfs maximum with Canadian Dams.
FLOW IN CFS
(Thousands)
24
22
20
18
16
14
12
10
8
6
4
2
0
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
TIME IN DAYS (BEGIN 2 JANUARY)
FXISTING
MODIFIED

DA
FILM
3